

New records of bee flies (Diptera, Bombyliidae) from Cuatro Ciénegas, Coahuila, Mexico

Omar Ávalos-Hernández^{1,3}, Joel Kits², Marysol Trujano-Ortega¹,
Uri Omar García-Vázquez¹, Zenón Cano-Santana³

1 Museo de Zoología, Facultad de Ciencias, UNAM, Apdo. Postal 70-399. México 04510 D.F. México **2** 6864
Gallagher Rd., Ottawa, Canada **3** Departamento de Ecología y Recursos Naturales, Facultad de Ciencias,
UNAM Circuito Exterior s/n, Ciudad Universitaria, México 04510 D.F. México

Corresponding author: Omar Ávalos-Hernández (omar_avalos@yahoo.com)

Academic editor: T. Dikow | Received 27 March 2014 | Accepted 16 June 2014 | Published 3 July 2014

<http://zoobank.org/C2F172F9-0159-4CB8-8008-7649B690CEF0>

Citation: Ávalos-Hernández O, Kits J, Trujano-Ortega M, García-Vázquez UO, Cano-Santana Z (2014) New records of bee flies (Diptera, Bombyliidae) from Cuatro Ciénegas, Coahuila, Mexico. ZooKeys 422: 49–85. doi: 10.3897/zookeys.422.7598

Abstract

Forty one new records of species of Bombyliidae are reported for Coahuila in northeastern Mexico. Nine of these species are reported for the first time for the country. The specimens were collected in the Cuatro Ciénegas Basin and Sierra La Madera mountains during 2007–2013. The modified distributions of species are discussed. The gaps in the distribution of many species suggest an undersampling of this group of insects in the north of Mexico.

Keywords

Biodiversity, distribution expansion, Nearctic region, desert fauna

Introduction

The bee flies (Bombyliidae) belong to the superfamily Asiloidea and are the eighth most diverse family within Diptera with 5382 described species (Pape et al. 2011). All species of Bombyliidae are parasitoids, hyperparasitoids or predators of immature stages of Coleoptera, Hymenoptera, Lepidoptera, Orthoptera, Neuroptera, and

Diptera (Yeates and Greathead 1997, Boesi et al. 2009). Unlike most other taxa, bee flies are most abundant and diverse in arid and semiarid portions of the world (Hull 1973, Evenhuis 1989). In the immature stages these insects function as a natural control for populations of other insects and as adults are efficient pollinators (Motten et al. 1981, Kearns 2001).

Some faunistic studies have been completed including Bombyliidae in Mexico (Rodríguez-Ortuño 1989, Ávalos-Hernández 2007), but the northern region of the country is poorly known for this family. Although Evenhuis and Greathead (1999) list 15 species of Bombyliidae for Coahuila, species richness in this state is probably higher as suggested by the richness of surrounding Mexican states with similar or even smaller size and similar ecosystems (e.g., Nuevo León, 37 species; Durango, 41 species) and of Texas (171 species), the nearest USA state.

Cuatro Ciénegas Basin in the northeast of Coahuila is especially interesting because of its geological history and the presence of water ponds and gypsum dunes, which create a different environment from the surrounding areas. The basin was a shallow sea from the Pangea breakup until the Eocene, 40 Ma, when the Sierra Madre Oriental in the east of Mexico rose isolating the Basin from the Atlantic Ocean (Souza et al. 2012). The physiology of Cuatro Ciénegas bacteria is similar to that of marine species, with which they are closely related (Souza et al. 2006). According to Moreno-Letelier et al. (2012) this evidence indicates that some water was kept trapped in the Basin when the ocean retreated giving the basin unique characteristics. These characteristics produced a high number endemism for vertebrates and prokaryotes in Cuatro Ciénegas (Souza et al. 2006, 2012).

The present study is the first known long-term systematic sampling of Diptera in Cuatro Ciénegas. The objective of this project is to complete the list of species of Bombyliidae in the basin and surrounding mountains. In this paper, 41 new species-level records for Coahuila from Cuatro Ciénegas are presented, including nine new records for Mexico. The modified distributions of the species are discussed.

Methods

Beeflies were collected at nine sites from Cuatro Ciénegas Basin and Sierra La Madera within the Municipality of Cuatrociénegas (Figure 1). Abbreviations for study sites (Table 1) are used throughout. Samplings were performed during 2007-2013, using aerial net and a Malaise trap. The Malaise trap had white polyester netting, was square in configuration, 210 cm tall and 120 cm wide and the collecting head located at the top. Trap was set from 9:00 to 17:00 when weather conditions allowed it. To avoid damage to the specimens no killing agent was used, insects were extracted at the end of the day. Specimens were pinned and labeled. Generic identification was carried out under a stereomicroscope according to the keys by Hall (1981b) and Kits et al. (2008). Species were identified by the first and second authors with specialized keys for each genus and comparison with museum specimens, keys used for identification of each

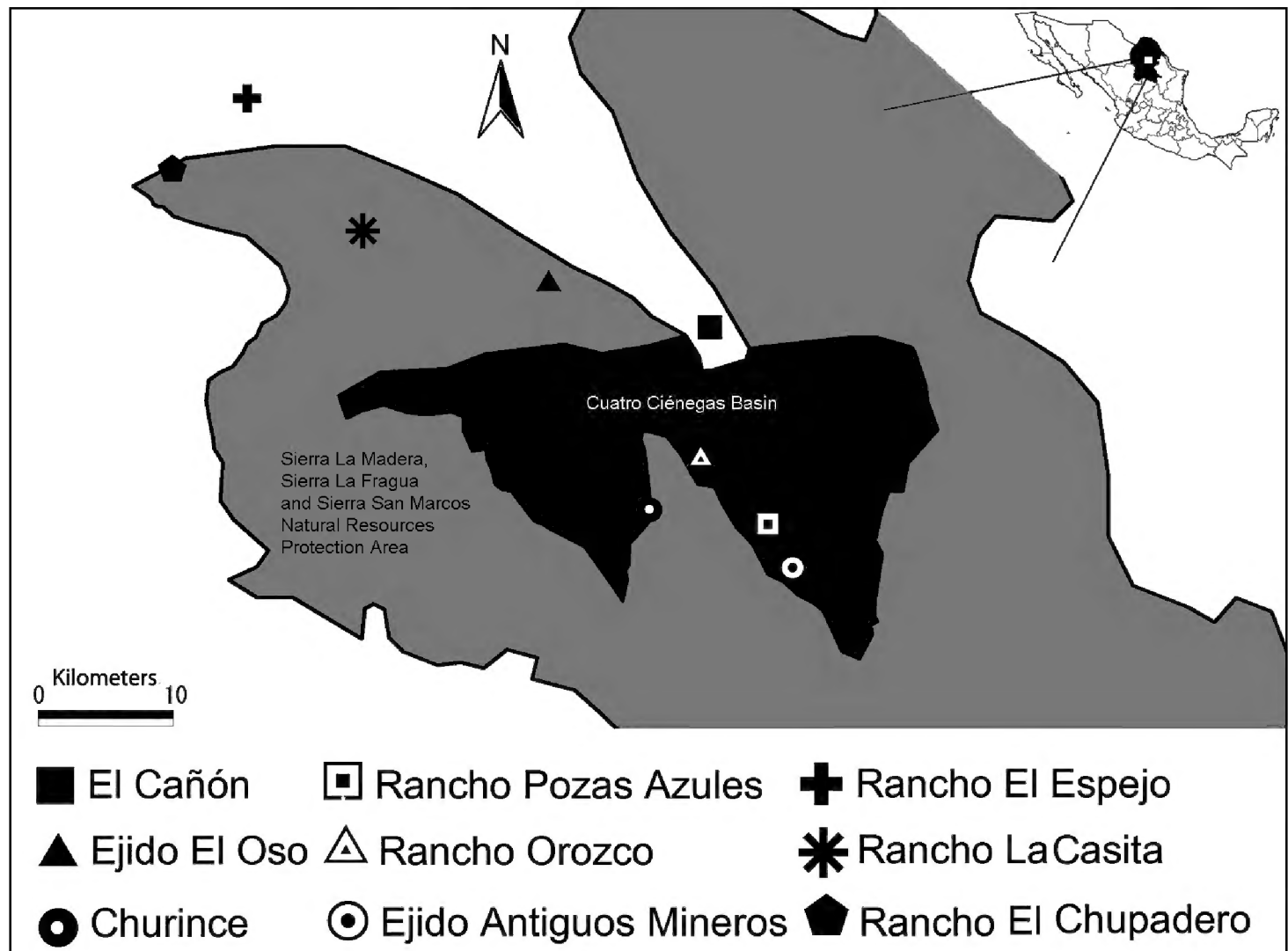


Figure 1. Field work sites. Cuatro Ciénegas basin is located in Coahuila at northeast of Mexico. Sierra La Madera is located at northwest of the basin.

genera are specified below. Taxonomic classification and distribution data are based on Evenhuis and Greathead (1999) and host data are based on Hull (1973), if not indicated otherwise. Distribution gaps are suggested as disjunct distribution patterns or the result of under sampling by comparing the location of records in Mexico with those in the southern states of the USA. All specimens are deposited in the Colección Nacional de Insectos (Instituto de Biología, Universidad Nacional Autónoma de México; CNIN-IBUNAM).

Results

A total of 41 new species-level records are presented for the state of Coahuila. Nine of these 41 species are recorded for the first time in Mexico, being their most southern records. Of the 15 species previously listed for Coahuila, two were collected during this study: *Heterostylum robustum* (Osten Sacken, 1877) (Material collected: CHU: Apr (1 M), Sep (1 M); EAM: Mar (2 M), Sep (1 F), Jun (2 F), Jul (1 F), Oct (1 F); ROR: Apr (1 F, 3 M), May (1 F, 2 M), Jul (3 F), Sep (1 F); RPA: Apr (1 F, 1 M), Jul (2 F, 2 M), Sep (1 M), Oct (2 M)); and *Anastoechus melanohalteralis* Tucker, 1907 (Material collected: EAM: Oct (1 M); ECA: Oct (1 F, 1 M); ROR: Oct (7 F, 6 M); RPA: Sep (1 M)).

Table 1. Field work sites in Cuatro Ciénegas. Vegetation according to Pinkava (1979).

	Site (Code)	Location	Altitude (m)	Vegetation
1	Churince (CHU)	N26°50'30", W102°08'10"	770	Gypsum dunes; sedges and marshes; mezquital, halophile
2	Rancho Orozco (ROR)	N26°52'18", W102°05'17"	740	Sedges and marshes; mezquital; halophile
3	Rancho Pozas Azules (RPA)	N26°49'39", W102°01'24"	710	Sedges and marshes; mezquital; halophile
4	Ejido Antiguos Mineros (EAM)	N26°46'58", W102°00'20"	725	Sedges and marshes; mezquital; halophile
5	El Cañón (ECA)	N27°00'34", W102°04'42"	780	Mezquital; desert scrub
6	Ejido El Oso (EEO)	N27°03'08", W102°13'35"	1085	Desert scrub; chaparral
7	Rancho El Espejo (REE)	N27°13'19", W102°30'19"	1425	Desert scrub; chaparral
8	Rancho El Chupadero (REC)	N27°10'07", W102°34'26"	1790	Desert scrub; chaparral; Pine-Oak forest
9	Rancho La Casita (RLC)	N27°06'45", W102°23'40"	1630	Desert scrub; chaparral; Pine-Oak forest

New records of the species included in this paper are from 17 genera for which modern revisions are available. Six taxa of *Hemipenthes* (3), *Lordotus* (1), *Paravilla* (1) and *Rhynchanthrax* (1) could not be identified accurately, being probably undescribed species. Identification of species in another 10 genera found in the study (e.g. *Villa*, *Chrysanthrax*, and *Exoprosopa*) is difficult and unreliable. The number of morphospecies and specimens collected of these genera are presented in Table 2. Six species of *Tmemophlebia* (1), *Geron* (1), *Exoprosopa* (3) and *Villa* (1) previously listed for Coahuila were probably collected but specimens of these genera are still being identified. Taxonomic work will continue, updates of the species list and descriptions of the new taxa will be published in subsequent papers.

A total of 28 genera were found during this study, of which 21 are new records for the state. Two genera previously listed for Coahuila (*Neacreotrichus* and *Relictiphthiria*) were not found in Cuatro Ciénegas area. With the new records presented here, the list of bee fly species in Coahuila increases to 56 (Table 2).

Subfamily Toxophorinae

Genus *Toxophora* Meigen

Remarks. *Toxophora* is distributed worldwide, being more diverse in the Afrotropical and Palearctic regions. Mexico's fauna includes three Neotropical species and five Nearctic species. All Nearctic species of Mexico were distributed in the western half of

Table 2. Updated list of genera and species of Bombyliidae in Coahuila (* species not collected in this study, but recorded previously in Coahuila; ** species most likely collected in this study, but identification not yet certain).

Subfamily, genus and species name	New record	Unidentifiable material
PHTHRIINAE		
<i>Neacreotrichus</i> Cockerell		
* <i>Neacreotrichus consors</i> (Osten Sacken, 1887)		
<i>Poecilognathus</i> Jaennicke	Coahuila	1 morphospecies, 3 specimens
<i>Relictiphthiria</i> Evenhuis		
* <i>Relictiphthiria psi</i> (Cresson, 1919)		
<i>Tmemophlebia</i> Evenhuis		1 morphospecies, 21 specimens
** <i>Tmemophlebia coquilletti</i> (Johnson, 1902)		
TOXOPHORINAE		
<i>Geron</i> Meigen		2 morphospecies, 194 specimens
** <i>Geron holosericeus</i> Walker, 1849		
<i>Systropus</i> Wiedemann	Coahuila	1 morphospecies, 5 specimens
<i>Toxophora</i> Meigen	Coahuila	
<i>Toxophora maxima</i> Coquillett, 1886	Coahuila	
<i>Toxophora virgata</i> Osten Sacken, 1877	Coahuila	
BOMBYLIINAE		
<i>Anastoechus</i> Osten Sacken		
<i>Anastoechus melanohalteralis</i> Tucker, 1907		
<i>Bombylius</i> Linnaeus		
<i>Bombylius (Bombylius) frommerorum</i> Hall & Evenhuis, 1980	Coahuila	
* <i>Bombylius (Bombylius) sylphae</i> Evenhuis, 1984		
* <i>Bombylius (Parabombylius) aleophilus</i> (Hall & Evenhuis, 1981)		
* <i>Bombylius (Parabombylius) coahuilensis</i> (Hall & Evenhuis, 1981)		
* <i>Bombylius (Parabombylius) paradoxus</i> (Hall & Evenhuis, 1981)		
* <i>Bombylius (Parabombylius) syndesmus</i> (Coquillett, 1894)		
<i>Conophorus</i> Meigen	Coahuila	1 morphospecies, 3 specimens
<i>Heterostylum</i> Macquart		
<i>Heterostylum croceum</i> Painter, 1930	Mexico	
<i>Heterostylum robustum</i> (Osten Sacken, 1877)		
<i>Lordotus</i> Loew	Coahuila	1 morphospecies, 38 specimens
<i>Lordotus diplasus</i> Hall, 1954	Coahuila	
<i>Lordotus divisus</i> Cresson, 1919	Coahuila	
<i>Lordotus perplexus</i> Johnson & Johnson, 1959	Coahuila	
<i>Triploechnus</i> Edwards	Coahuila	
<i>Triploechnus novus</i> (Williston, 1893)	Coahuila	
LOMATIINAE		
<i>Ogcodocera</i> Macquart	Coahuila	
<i>Ogcodocera analis</i> Williston, 1901	Coahuila	
TOMOMYZINAE		
<i>Paracosmus</i> Osten Sacken	Coahuila	
<i>Paracosmus (Paracosmus) morrisoni</i> Osten Sacken, 1887	Coahuila	
ANTHRACINAE		
<i>Anthrax</i> Scopoli	Coahuila	
<i>Anthrax atriplex</i> Marston, 1970	Coahuila	

Subfamily, genus and species name	New record	Unidentifiable material
<i>Anthrax cybele</i> (Coquillett, 1894)	Mexico	
<i>Anthrax georgicus</i> Macquart, 1834	Coahuila	
<i>Anthrax irroratus</i> Say, 1823	Coahuila	
<i>Anthrax oedipus</i> Fabricius, 1805	Coahuila	
<i>Anthrax pauper</i> (Loew, 1869)	Mexico	
<i>Anthrax seriepunctatus</i> (Osten Sacken, 1886b)	Coahuila	
<i>Aphoebantus</i> Loew	Coahuila	4 morphospecies, 236 specimens
<i>Chrysanthrax</i> Osten Sacken	Coahuila	6 morphospecies, 240 specimens
<i>Dipalta</i> Osten Sacken	Coahuila	
<i>Dipalta serpentina</i> (Osten Sacken, 1877)	Coahuila	
<i>Exoprosopa</i> Macquart		9 morphospecies, 395 specimens
**<i>Exoprosopa aztec</i> Painter & Painter, 1969		
**<i>Exoprosopa butleri</i> Johnson & Johnson, 1958		
**<i>Exoprosopa dorcadion</i> Osten Sacken, 1877		
<i>Hemipenthes</i> Loew	Coahuila	3 morphospecies, 146 specimens
<i>Hemipenthes jaennickeana</i> (Osten Sacken, 1886a)	Coahuila	
<i>Hemipenthes lepidota</i> (Osten Sacken, 1886b)	Coahuila	
<i>Hemipenthes scylla</i> (Osten Sacken, 1887)	Coahuila	
<i>Hemipenthes sinuosa</i> (Wiedemann, 1821)	Coahuila	
<i>Lepidanthrax</i> Osten Sacken	Coahuila	
<i>Lepidanthrax arizonensis</i> Hall, 1976	Mexico	
<i>Lepidanthrax disiunctus</i> (Wiedemann, 1830)	Coahuila	
<i>Lepidanthrax hesperus</i> Hall, 1976	Coahuila	
<i>Lepidanthrax hyposcelus</i> Hall, 1976	Coahuila	
<i>Lepidanthrax proboscideus</i> (Loew, 1869)	Coahuila	
<i>Ligyra</i> Newman	Coahuila	1 morphospecies, 2 specimens
<i>Neodiplocampta</i> Curran	Coahuila	
<i>Neodiplocampta (Neodiplocampta) miranda</i> Hull & Martin, 1974	Coahuila	
<i>Paravilla</i> Painter	Coahuila	1 morphospecies, 48 specimens
<i>Paravilla edititoides</i> (Painter, 1933)	Coahuila	
<i>Paravilla flavipilosa</i> (Cole, 1923)	Coahuila	
<i>Paravilla parvula</i> Hall, 1981a	Coahuila	
<i>Paravilla separata</i> (Walker, 1852)	Mexico	
<i>Poecilanthrax</i> Osten Sacken	Coahuila	
<i>Poecilanthrax effrenus</i> (Coquillett, 1887)	Coahuila	
<i>Poecilanthrax fasciatus</i> Johnson & Johnson, 1957	Mexico	
<i>Poecilanthrax hyalinipennis</i> Painter & Hall, 1960	Mexico	
<i>Poecilanthrax poecilogaster</i> (Osten Sacken, 1886b)	Coahuila	
<i>Rhynchanthrax</i> Painter	Coahuila	1 morphospecies, 70 specimens
<i>Rhynchanthrax capreus</i> (Coquillett, 1887)	Mexico	
<i>Rhynchanthrax texanus</i> (Painter, 1933)	Coahuila	
<i>Thyridanthrax</i> Osten Sacken	Coahuila	
<i>Thyridanthrax pallidus</i> (Coquillett, 1887)	Mexico	
<i>Thyridanthrax selene</i> (Osten Sacken, 1886b)	Coahuila	
<i>Villa</i> Lioy		9 morphospecies, 115 specimens
**<i>Villa fumicosta</i> Painter & Painter, 1962		
<i>Xenox</i> Evenhuis	Coahuila	
<i>Xenox xylocopae</i> (Marston, 1970)	Coahuila	

the country. These two new records represent the first of this genus in Coahuila and the most eastern distribution of the Nearctic species in the country. The New World species of this genus were keyed using Cunha et al. (2011).

***Toxophora maxima* Coquillett, 1886**

Figure 2a, b

Material examined. CHU: Jul (1 M); EEO: Jul (2 F, 2 M), Oct (1 F, 3 M).

Known Nearctic records. Mexico (Baja California, Baja California Sur, Coahuila); USA (Arizona, California, Idaho, Kansas, New Mexico, Oklahoma, Oregon, Texas).

Comments. In Mexico *T. maxima* was only known from Baja California Peninsula and now Coahuila. This apparent gap in its distribution is probably due to under-sampling. Sampling of the intermediate zones is necessary to know if these populations form a continuous unit as they do in the southern states of USA.

***Toxophora virgata* Osten Sacken, 1877**

Figure 2c, d

Material examined. EAM: Jun (1 F, 1 M), Jul (1 F); CHU: Aug (1 M), Oct (1 M); EEO: Jul (1 M), Oct (1 F, 1 M); RLC: Jun (1 M); ROR: Apr (1 F, 2 M); RPA: Oct (1 F).

Known Nearctic records. Mexico (Baja California Sur, Coahuila, Sonora); USA (Arizona, California, Colorado, Georgia, Idaho, Nevada, New Mexico, Oklahoma, Texas, Utah).

Known hosts. *Odynerus* sp. (Vespidae); *Stenodynerus toltecus* Saussure (Vespidae).

Comments. This species is present in the all southwestern states of the USA and northwest of Mexico. This is the first record in the northeast of Mexico. The species is probably also present in Chihuahua, between Sonora and Coahuila.

Subfamily Bombyliinae

Genus *Bombylius* Linnaeus

Remarks. With 278 described species, *Bombylius* is the second most diverse genus of Bombyliidae. It has a worldwide distribution being especially diverse in the Palearctic and Nearctic regions. One endemic species is present in Coahuila: *B. (Parabombylius) coahuilensis* (Hall & Evenhuis, 1981). Four other species are reported for the state: *B. sylphae* Evenhuis, 1984, *B. aleophilus* (Hall & Evenhuis, 1981), *B. paradoxus* (Hall & Evenhuis, 1981), *B. syndesmus* (Coquillett, 1894). A review with identification keys for Nearctic species is presented in Hall and Evenhuis (1980), later Evenhuis (1984) revised and present keys for the *comanche* group of America.

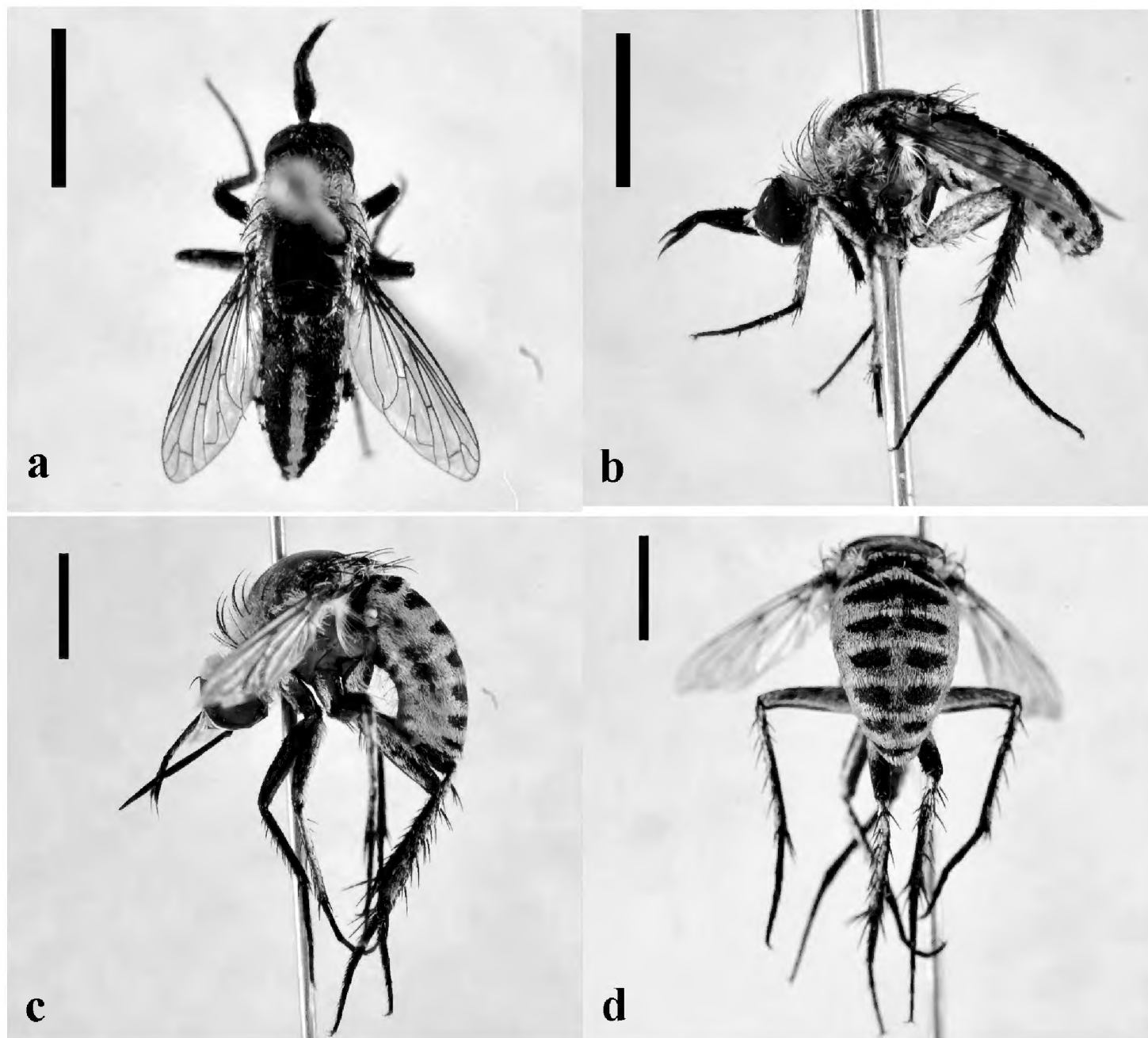


Figure 2. *Toxophora*. *T. maxima*, male (CNIN 1115) **a** dorsal view **b** lateral view; *T. virgata*, male (CNIN 1109) **c** lateral view **d** posterior view. All scale bars: 3 mm.

***Bombylius (Bombylius) frommerorum* Hall & Evenhuis, 1980**

Figure 3

Material examined. EEO: Aug (1 M), Oct (1 F).

Known Nearctic records. Mexico (Chihuahua, Coahuila); USA (Arizona, New Mexico, Texas).

Comments. This species is restricted to the southwest of the USA and north of Mexico.

Genus *Heterostylum* Macquart

Remarks. The genus is only present in Nearctic and Neotropical regions. Although not as diverse as other genera (only 12 species), specimens from some species are abun-

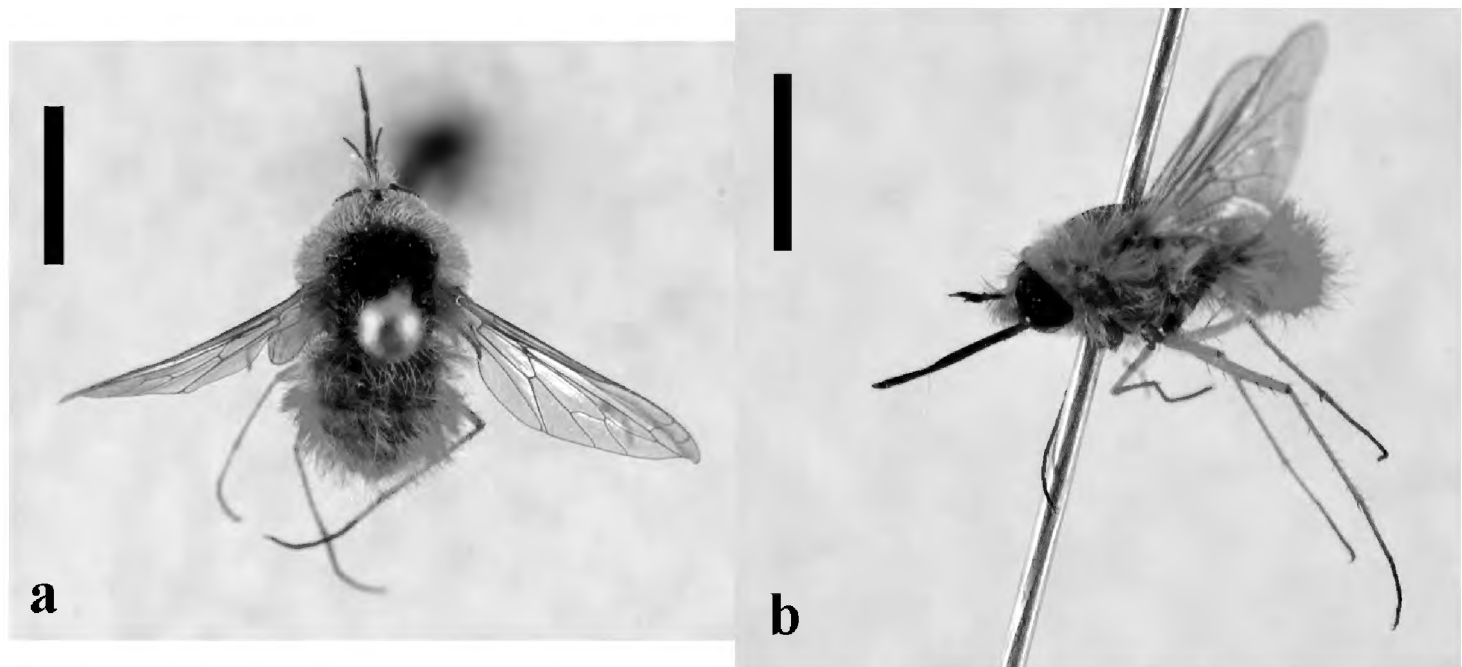


Figure 3. *Bombylius* (*B.*) *frommerorum*, female (CNIN 772) **a** dorsal view **b** lateral view. All scale bars: 3 mm.

dant in the field. *Heterostylum robustum* was previously known from Coahuila and was collected during this study. This species is distributed from Canada to central Mexico. There are two revisions for this genus that contains identification keys, one by Hall and Evenhuis (1980) and the more recent by Cunha et al. (2007).

Heterostylum croceum Painter, 1930

Figure 4

Material examined. REE: Apr (1 F).

Known Nearctic records. Mexico (Coahuila); USA (Colorado, Kansas, Missouri, New Mexico, Texas).

Comments. *Heterostylum croceum* is recorded for the first time in Mexico; previously known from the southern-central United States. Hall and Evenhuis (1980) suggest that *H. croceum* may be related to *H. engelhardti* Painter, 1930 or even be a subspecies of that taxon, *Heterostylum croceum* is the eastern form and *H. engelhardti* the western form (Arizona, California, Texas, Utah) although both species are present in Texas. Cunha et al. (2007) comment that *H. engelhardti* can be distinguished by the presence of white to very pale yellow hair and brown-tipped hairs on the abdomen compared with the darker yellow hairs in *H. croceum*.

Genus *Lordotus* Loew

Remarks. Most of the 29 species in this exclusively Nearctic genus are distributed in the southwest of the USA and north of Mexico, although eight species are present in the northwest of the USA (*L. apicula* Coquillett, 1887; *L. bipartitus* Painter, 1940; *L. diversus* Coquillett, 1891; *L. gibbus* Loew, 1863; *L. miscellus* Coquillett, 1887; *L.*

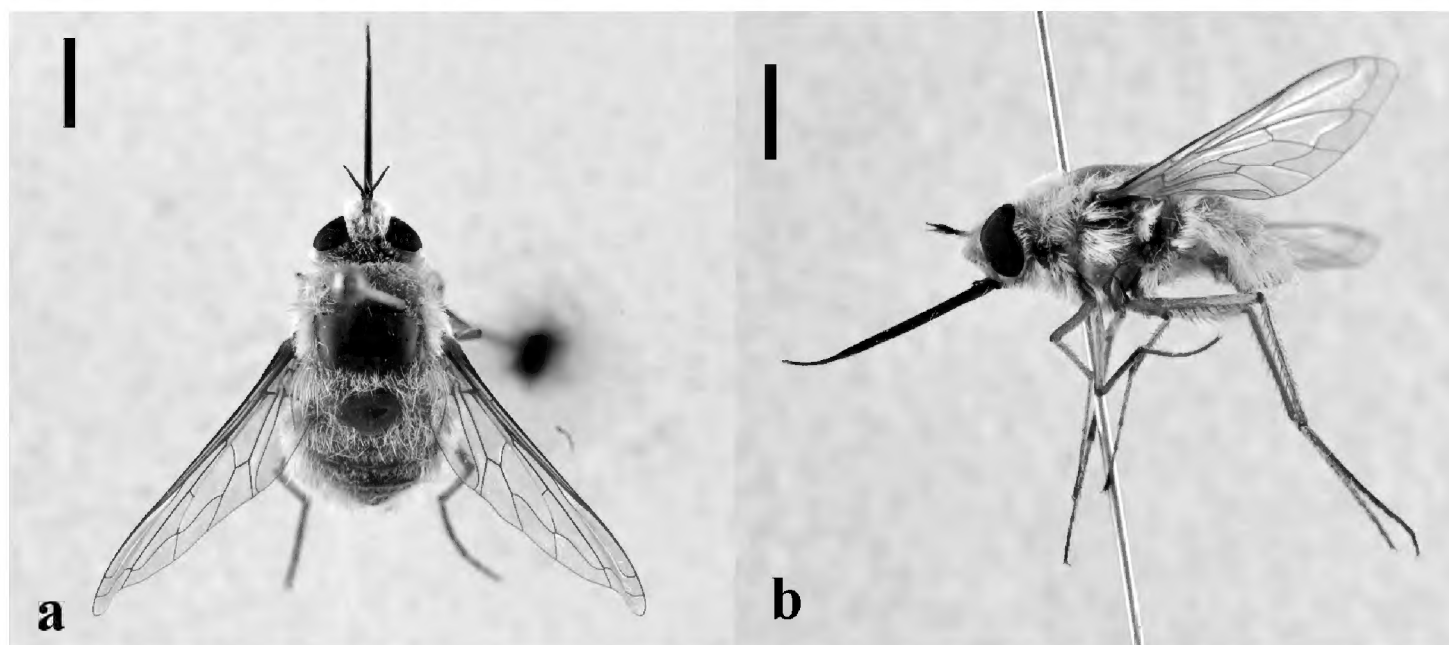


Figure 4. *Heterostylum croceum*, female (CNIN 858) **a** dorsal view **b** lateral view. All scale bars: 3 mm.

pulchrissimus Williston, 1893; *L. striatus* Painter, 1940; *L. zona* Coquillett, 1887). The three species present in Coahuila are also found in California; their distribution probably includes all northern states of Mexico. Hall (1954) and Hall and Evenhuis (1982) present reviews of the genus and keys to the species.

Lordotus diplasus Hall, 1954

Figure 5a, b

Material examined. CHU: Sep (2 M); RLC: Sep (2 M); RPA: Sep (1 F).

Known Nearctic records. Mexico (Coahuila, Zacatecas); USA (Arizona, California, New Mexico).

Lordotus divisus Cresson, 1919

Figure 5c

Material examined. ECA: Mar (1 M), Apr (2 M); EEO: Apr (16 M); REE: Apr (4 M); ROR: Apr (1 M).

Known Nearctic records. Mexico (Coahuila, Baja California); USA (Arizona, California, Nevada, New Mexico, Texas).

Lordotus perplexus Johnson & Johnson, 1959

Figure 5d, e

Material examined. CHU: Apr (1 H), ECA: Apr (1 H); EEO: Apr (4 F); REE: Apr (7 F); ROR: Apr (1 F).

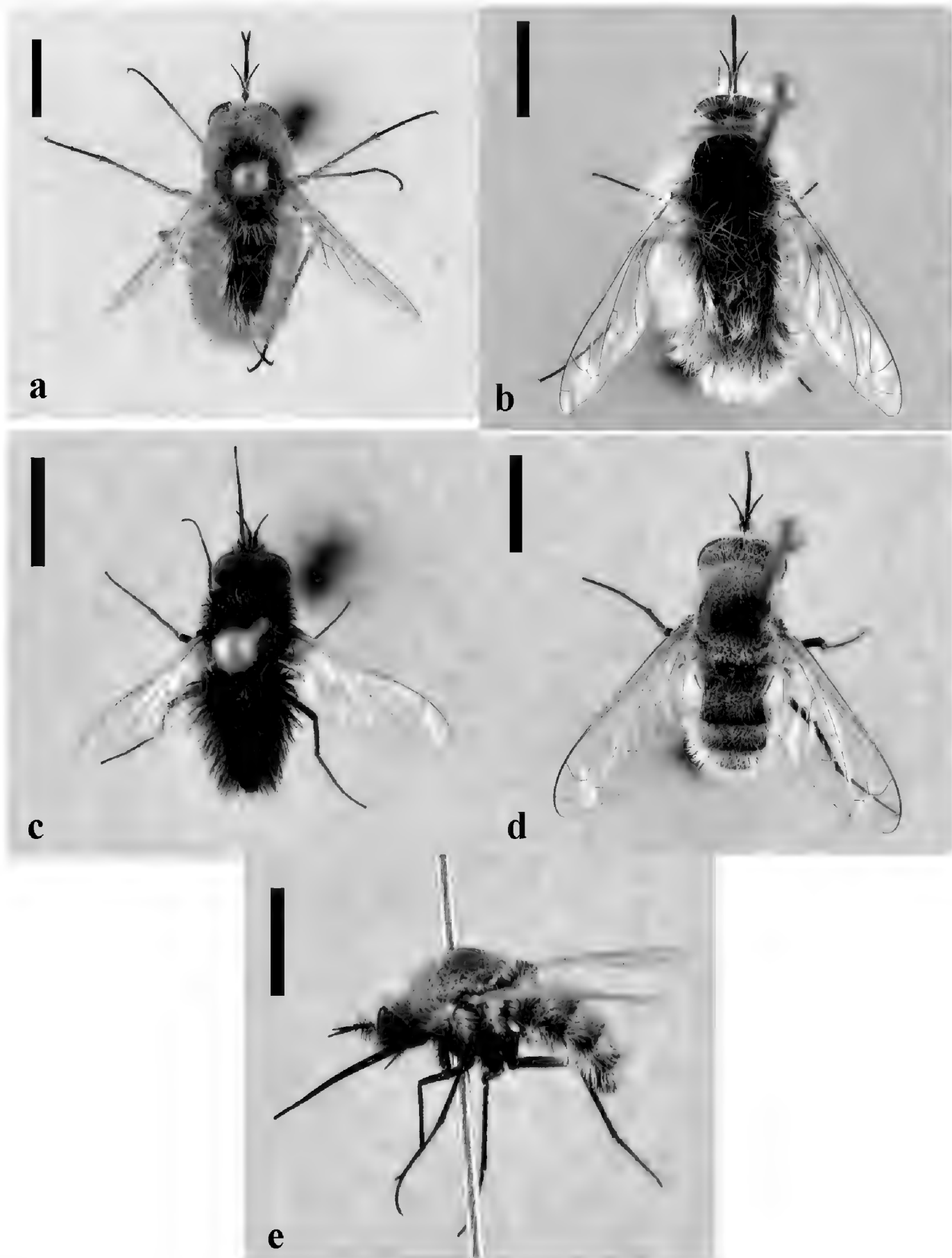


Figure 5. *Lordotus*. *L. diplasus*, **a** female (CNIN 774) dorsal view **b** male (CNIN 861) dorsal view **c** *L. divisus*, male (CNIN 777) dorsal view; *L. perplexus*, female (CNIN 801) **d** dorsal view **e** lateral view. All scale bars: 3 mm.

Known Nearctic records. Mexico (Baja California, Coahuila, Sinaloa, Sonora); USA (Arizona, California, Nevada, Texas).

Comments. *Lordotus perplexus* has the most southern distribution in the genus, reaching Sinaloa on the Pacific coast.

Genus *Triploechus* Edwards

Remarks. Four species of *Triploechus* are present in Nearctic region: *T. luridus* Hall, 1975; *T. novus* (Williston, 1893); *T. sackeni* (Bigot, 1892); *T. stagei* Hall, 1975. Of these *T. stagei* is endemic to Mexico and *T. novus* has the widest distribution of this genus, being present in the south of the USA and center of Mexico. Hall and Evenhuis (1981) present a revision and key for species for this genus.

Triploechus novus (Williston, 1893)

Figure 6

Material examined. CHU: Apr (7 F, 6 M); REE: Apr (1 M); RPA: Apr (1 M).

Known Nearctic records. Mexico (Coahuila, Durango, San Luis Potosí, Sonora); USA (Arizona, California, Nevada, New Mexico, Texas).

Comments. This is a widespread and apparently common species. All specimens were collected in April so it may have a short flight season.

Subfamily Lomatiinae

Genus *Ogcodocera* Macquart

Remarks. The only two species in this genus have been collected from the neotropical part of Mexico to north of the USA and Canada. *Ogcodocera leucoprocta* (Wiedemann, 1828), not sampled during this study, is present in the whole Nearctic region from Canada to south of Mexico.

Ogcodocera analis Williston, 1901

Figure 7

Material examined. EEO: Aug (2 M), Oct (1 M).

Known Nearctic records. Mexico (Coahuila, Guerrero, Morelos); USA (Arizona, Texas).

Comments. This record is the first of this species in the north of Mexico, but it has been previously collected in the south of Mexico and in the south of USA, and thus is probably distributed across the whole country. Unlike *O. leucoprocta*, *O. analis* has its most northern distribution in Arizona and Texas.



Figure 6. *Triploechnus novus*, female (CNIN 1237) dorsal view. Scale bar: 3 mm.



Figure 7. *Ogcodocera analis*, male (CNIN 146) dorsal view. Scale bar: 3 mm.

Subfamily Tomomyzinae

Genus *Paracosmus* Osten Sacken

Remarks. All five extant species of *Paracosmus* have Nearctic distributions, and all are present in California. Two of these species have been collected in the northwest of Mexico (*P. (Actherosia) rubicundus* Melander, 1950 and *P. (Paracosmus) morrisoni* Osten Sacken, 1887).

Paracosmus (Paracosmus) morrisoni Osten Sacken, 1887

Figure 8

Material examined. EAM: Apr (1 F, 1 M); CHU: Apr (2 M), Jul (1 F), Aug (2 F); ECA: Apr (1 M); EEO: May (1 F); REE: Apr (1 F); ROR: Apr (2 M), May (1 F, 3 M); RPA: Apr (1 F).

Known Nearctic records. Mexico (Coahuila, Sonora); USA (Arizona, California, Nevada, Texas).

Comments. *Paracosmus (P.) morrisoni* has the widest distribution within this genus, but in Mexico had previously only been recorded in Sonora. This record represents the most eastern distribution for the genus in the country.

Subfamily Anthracinae

Genus *Anthrax* Scopoli

Remarks. This is a diverse genus with 248 species worldwide. Two old but complete revisions of the genus, including distribution maps and keys, were made by Marston (1963, 1970). Thanks to these *Anthrax* species can be easily identified. Some *Anthrax* species are widely distributed occupying two biogeographic regions. From the seven *Anthrax* species collected in this study in Coahuila, just *A. cybele* (Coquillett, 1894) has a restricted distribution. The other six species are widespread across the Nearctic region. Two species of *Anthrax* are reported for the first time for Mexico.

Anthrax atriplex Marston, 1970

Figure 9a

Material examined. EAM Apr (1 F); ROR: Oct (2 M); RPA: Aug (1 M); Sep (1 M); Oct (1 F, 2 M).

Known Nearctic records. Mexico (Baja California Sur, Coahuila, Durango, Sonora, Tamaulipas); USA (Arizona, California, New Mexico, Oregon, Texas, Utah).

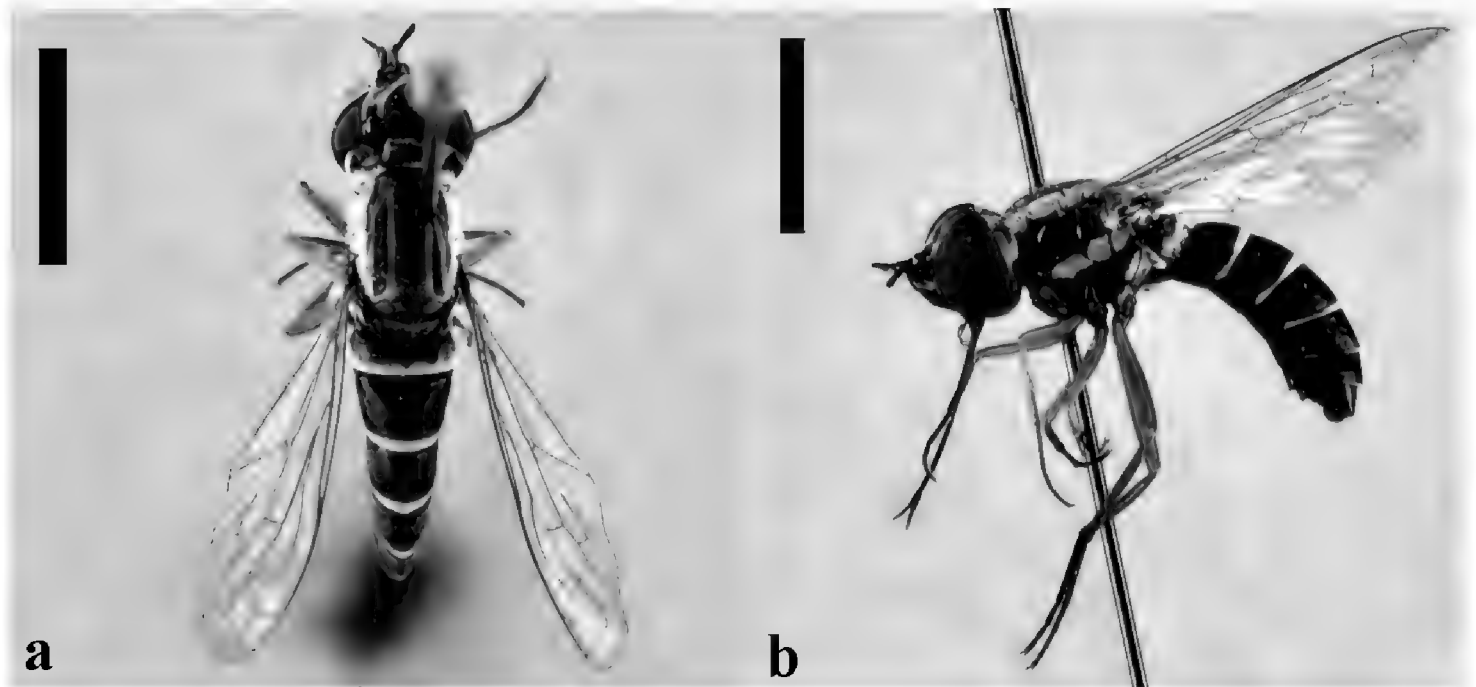


Figure 8. *Paracosmus (P.) morrisoni*, male (CNIN 832) **a** dorsal view **b** lateral view. All scale bars: 3 mm.

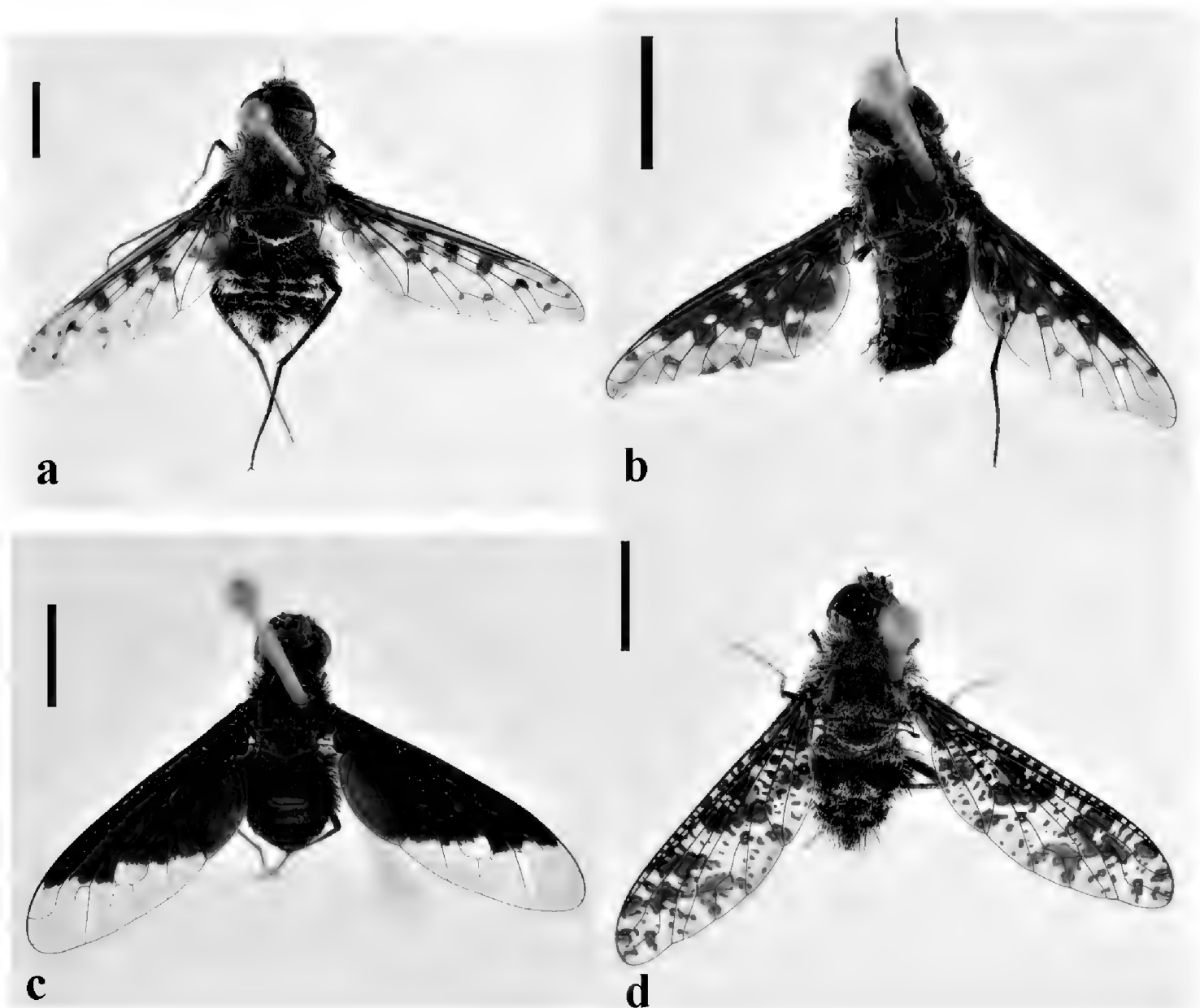


Figure 9. *Anthrax* part I. **a** *A. atriplex*, male (CNIN 1098) dorsal view **b** *A. cybele*, male (CNIN 1087) dorsal view **c** *A. georgicus*, female (CNIN 1071) dorsal view **d** *A. irroratus*, male (CNIN 1027) dorsal view. All scale bars: 3 mm.

Known host. *Megachile gentilis* Cresson (Megachilidae).

Comments. This species may be present in all the north of Mexico, including Chihuahua, Nuevo León and possibly Sinaloa.

***Anthrax cybele* (Coquillett, 1894)**

Figure 9b

Material examined. ECA: Apr (2 F); EEO: Apr (1 M).

Known Nearctic records. Mexico (Coahuila); USA (Arizona, California).

Comments. This is a rare species flying in April. Its distribution is disjunct so far, present in the southwest of the USA and northeast of Mexico. It is probably also found in New Mexico and Texas in the USA and Sonora and Chihuahua in Mexico.

***Anthrax georgicus* Macquart, 1834**

Figure 9c

Material examined. EAM: Mar (1 F), Apr (1 M), Jun (1 F, 2 M), Jul (2 F), Sep (2 M); ROR: Apr (1 F), Sep (1 M); RPA: Mar (1 M), Apr (1 F, 1 M), Jul (2 F, 1 M), Sep (6 F, 3 M), Oct (6 F, 3 M).

Known Nearctic records. Canada (Alberta, British Columbia, Manitoba, Northwest Territory, Ontario, Quebec, Saskatchewan); Mexico (Coahuila, Guerrero, Michoacán de Ocampo, Morelos, Nuevo León, Puebla, Sonora, Veracruz); USA (Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming).

Comments. The range of *A. georgicus* includes all North America and Central America (Nicaragua, Costa Rica) covering a wide diversity of habitats and environmental conditions. Common in the rainy season and present in the dry season (March), this species is probably present in most if not all states of Mexico, but has only been collected in eight of them.

***Anthrax irroratus* Say, 1823**

Figure 9d

Material examined. EAM: Apr (1 M), Aug (2 M), Oct (1 M); ECA: Apr (1 F), May (1 F, 1 M); EEO: Apr (2 F), Jul (4 F), Aug (1 M); REC: Apr (3 F, 10 M), Aug (1 M); REE: Aug (1 M); RLC: Jul (6 F, 10 M); ROR: Feb (1 M), Aug (5 M), Sep (1 M); RPA: Apr (1 M), Aug (2 M).

Known Nearctic records. Canada (Alberta, British Columbia, Manitoba, Northwest Territory, Nova Scotia, Ontario, Quebec, Saskatchewan); Mexico (Baja California, Baja California Sur, Coahuila, Colima, Guerrero, Michoacán, Morelos, Nayarit, Puebla, San Luis Potosí, Sinaloa, Sonora, Veracruz, Zacatecas); USA (Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Idaho, Illinois, Indiana, Kansas, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, West Virginia, Wyoming).

Known hosts. *Megachile gentilis* Cresson (Megachilidae); *M. mendica* Cresson (Megachilidae); *Dianthidium heterulkei fraternum* Timberlake (Megachilidae); *Aschmendiella buconis denticulata* Cresson (Megachilidae); *Hylaeus asininus* Cockrell and Casad (Colletidae). Scott and Strickler (1992) also reared *A. irroratus* from *Megachile relativa* Cresson (Megachilidae) and *M. inermis* Provancher (Megachilidae).

Comments. *Anthrax irroratus*, like *A. georgicus* (above), is present in all of North America and reaches Central America and Caribbean islands (Honduras, Puerto Rico). More abundant than its congener, this species has been collected in 15 states in Mexico (including Oaxaca of the Neotropical region not listed above) and all regions of the USA. *A. irroratus* should be collected in any systematic, long term Bombyliidae sample in Mexico and the USA.

Anthrax oedipus Fabricius, 1805

Figure 10a

Material examined. ECA: Apr (1 F, 1 M), Jul (1 F); EEO: Apr (2 F, 1 M), May (1 F, 4 M), Jul (1 M); REC: Apr (1 F); REE: Apr (2 M); RLC: Jul (2 F, 4 M), Sep (1 F); RPA: Apr (1 M), Aug (1 M).

Known Nearctic records. Mexico (Baja California, Coahuila, Nayarit, Morelos, Sinaloa, Sonora); USA (Nevada, Texas).

Comments. Apparently closely related to *A. irroratus*, *A. oedipus* has a narrow distribution in the Nearctic region but is widely distributed in all South America. In the USA it has been collected only in two southern states, while it occurs in most of the northern states of Mexico and one central state (Morelos); it may be present in most areas from Texas to Argentina.

Anthrax pauper (Loew, 1869)

Figure 10b

Material examined. CHU: Apr (1 F, 1 M).

Known Nearctic records. Canada (Ontario); Mexico (Coahuila); USA (Alabama, Colorado, Illinois, Indiana, Kansas, Maryland, Massachusetts, Michigan, Nebraska, New Jersey, New Mexico, New York, Oklahoma, Pennsylvania, Texas, Utah, Vermont, Virginia, Wisconsin).

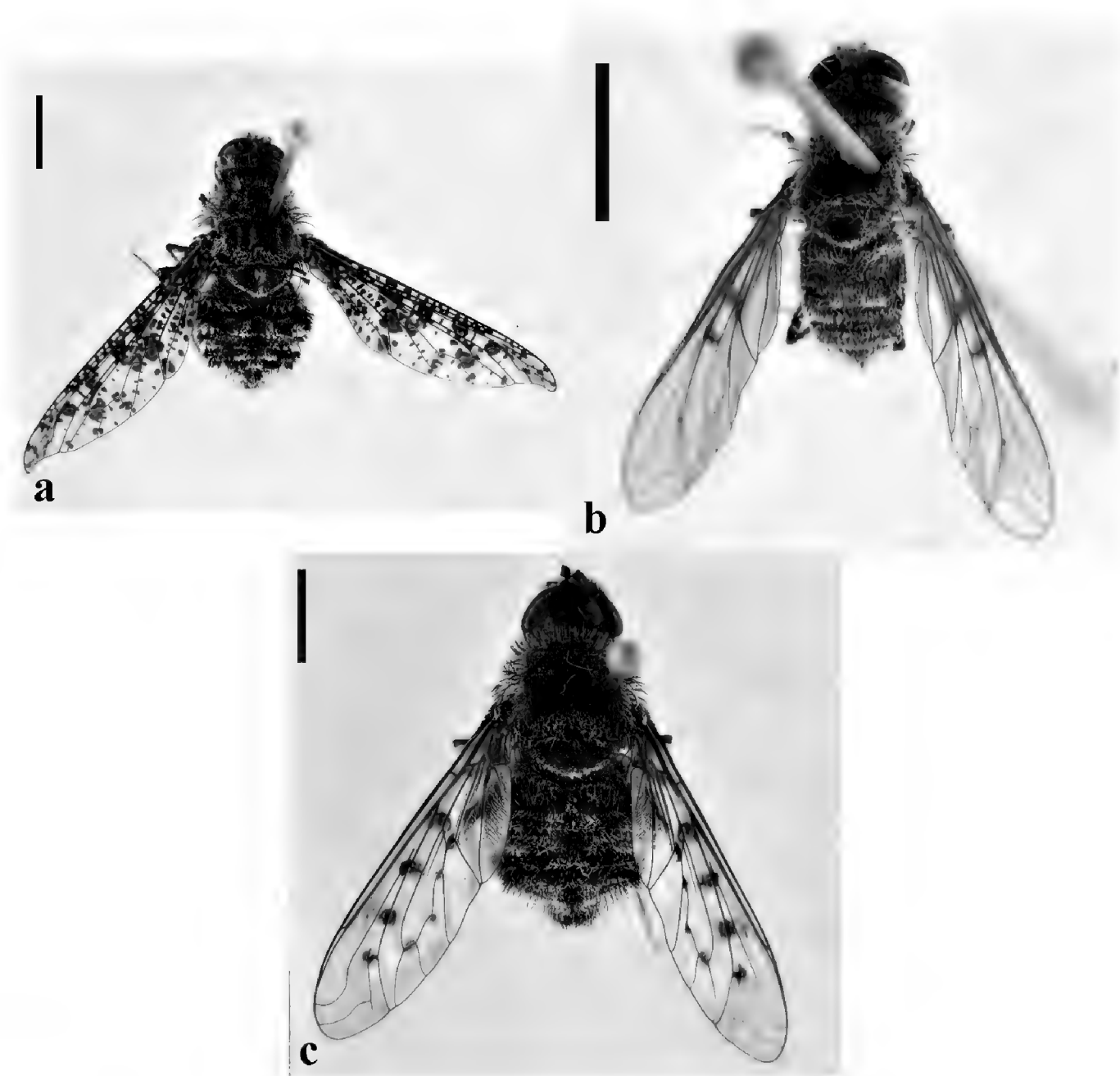


Figure 10. *Anthrax* part II. **a** *A. oedipus*, female (CNIN 1055) dorsal view **b** *A. pauper*, female (CNIN 1085) dorsal view **c** *A. seriepunctatus*, female (CNIN 1089) dorsal view. All scale bars: 3 mm.

Comments. With just two specimens collected, *A. pauper* appears to be a rare species in this region. This population is the most southern recorded of this species, mostly present in the center and east of the USA. Presumably adapted to colder climates, it is no coincidence that it was collected in the most elevated site sampled.

***Anthrax seriepunctatus* (Osten Sacken, 1886b)**

Figure 10c

Material examined. EAM: Jun (1 M); CHU: Apr (1 F), Aug (1 F), Sep (1 F); ECA: Jun (1 M); REE: Aug (1 F); RLC: Jun (1 F), Jul (1 F, 2 M).

Known Nearctic records. Mexico (Baja California Sur, Coahuila, Sonora, Puebla); USA (Arizona, Nevada, New Mexico, Texas).

Comments. This species is recorded mostly from the south of the USA and north of Mexico, but its presence in Puebla in central Mexico suggests a wider distribution within the country, at least in all northern states.

Genus *Dipalta* Osten Sacken

Remarks. *Dipalta* is a small genus with just two species. *Dipalta banksi* Johnson, 1921 is only present in eastern Canada and USA, while *D. serpentina* is distributed from Central America to the northern USA.

Dipalta serpentina (Osten Sacken, 1877)

Figure 11

Material examined. REC: Aug (1 M); RLC: Jul (1 M).

Known Nearctic records. Mexico (Coahuila, Guerrero, Hidalgo, México, Morelos, Puebla, San Luis Potosí, Sinaloa); USA (Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Texas, Utah, Washington, Wisconsin, Wyoming).

Known host. *Myrmeleon immaculatus* De Geer (Myrmeleontidae).

Comments. This species is probably present in all of Mexico, but this is the only record in the north of Mexico.

Genus *Hemipenthes* Loew

Remarks. *Hemipenthes* is equally diverse in the Nearctic (29 species), Neotropical (26 species) and Palearctic (37 species) regions, with just six species in the Oriental region and one in the Afrotropical region. Four species of this genus were collected in Coahuila. All of these have broad distributions but apparently from poor sampling because records are not continuous, especially in Mexico. Ávalos-Hernández (2009) recently published a revision of *Hemipenthes*, with a key for Nearctic species.

Hemipenthes jaennickeana (Osten Sacken, 1886a)

Figure 12a

Material examined. REC: Apr (18 F), Aug (4 F); REE: Feb (3 F); RLC: Mar (7 F), Jul (23 F, 3 M), Sep (3 F).

Known Nearctic records. Mexico (Coahuila, Morelos, Sonora); USA (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah).

Comments. Present mainly in the Pacific coast states of the USA and Mexico, from Oregon as far as Morelos in the center of Mexico. This record is the most eastern record in Mexico.



Figure 11. *Dipalta serpentina*, male (CNIN 215) dorsal view. Scale bar: 3 mm.

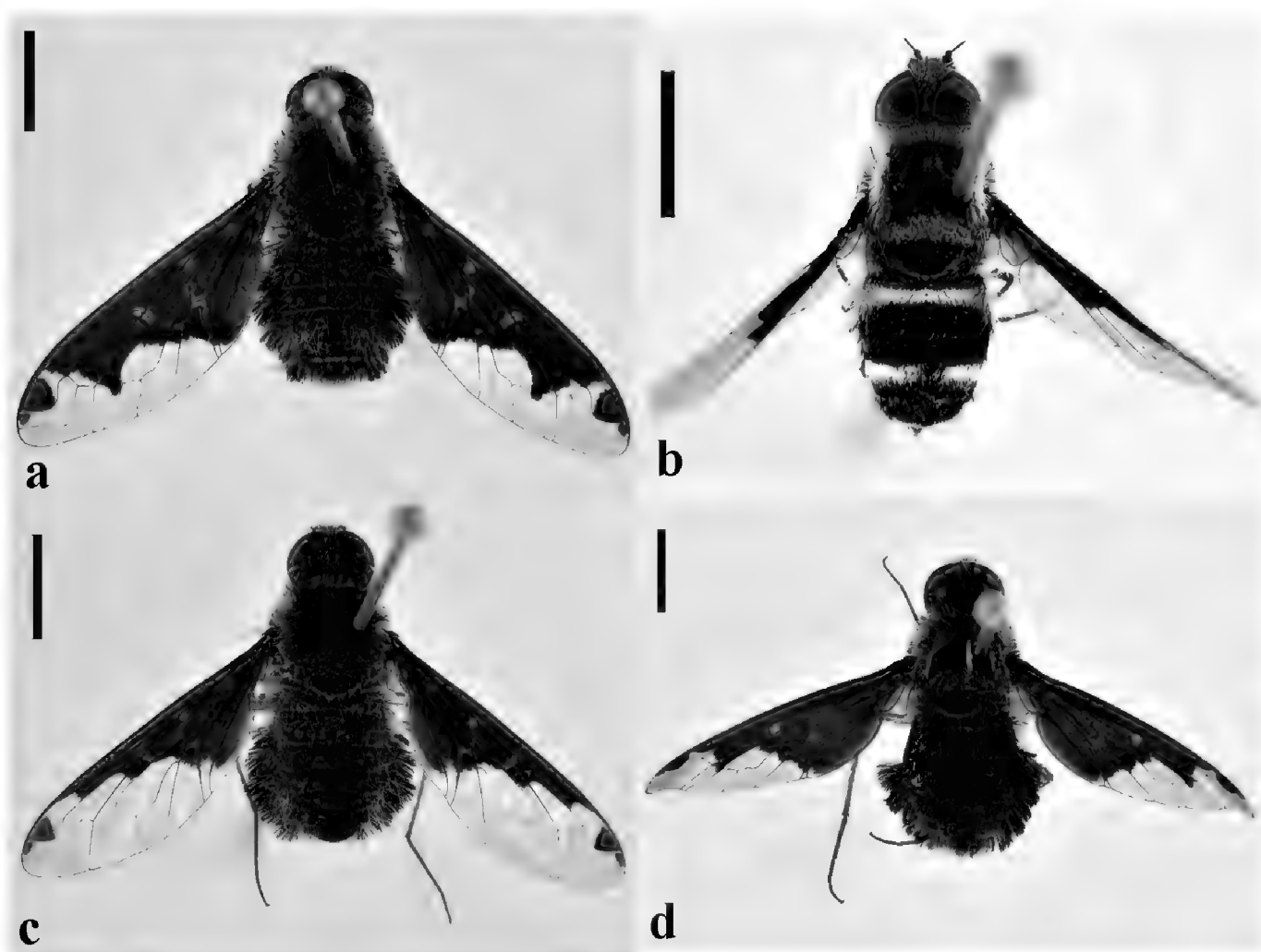


Figure 12. *Hemipenthes*. **a** *H. jaennickeana*, female (CNIN 1137) dorsal view **b** *H. lepidota*, female (CNIN 200) dorsal view **c** *H. scylla*, male (CNIN 725) dorsal view **d** *H. sinuosa*, female (CNIN 1134) dorsal view. All scale bars: 3 mm.

***Hemipenthes lepidota* (Osten Sacken, 1886b)**

Figure 12b

Material examined. EAM: Apr (1 M), Aug (1 F); CHU: Apr (1 F, 3 M), Aug (1 M); EEO: Jul (1 F, 4 M), Aug (1 F); REC: (1 M); REE: Apr (11 F, 2 M), Aug (1 F); RLC: Jun (1 F), Jul (3 F); RPA: Apr (1 F), Sep (4 F), Oct (2 F).

Known Nearctic records. Canada (Alberta); Mexico (Baja California, Baja California Sur, Coahuila, Chihuahua, Guerrero, Morelos, Puebla, San Luis Potosí, Sonora, Tamaulipas); USA (Arizona, California, Colorado, Idaho, Louisiana, Nevada).

Comments. This species is abundant in the rainy season in most of the Nearctic region but has not been collected in many states of Mexico or the USA where it probably is present.

***Hemipenthes scylla* (Osten Sacken, 1887)**

Figure 12c

Material examined. REC: Apr (23 M), Aug (7 M); REE: Feb (5 M), Apr (2 M); RLC: Mar (8 M), Jul (8 M), Sep (9 M).

Known Nearctic records. Mexico (Coahuila, Morelos, Guanajuato, Sonora); USA (Arizona, Texas).

Comments. Males of this species are abundant all year long but females are unknown. There is no explanation for this lack of females in the collections. Extreme sexual dimorphism and misidentification of females can be dismiss, since there is no *Hemipenthes* species from which only females are known. One possible explanation is that females life span is too short and therefor encounter probabilities are low. Distribution is discontinuous with populations present in central and northern Mexico and the southern USA; it is unknown whether this species is present in between these areas.

***Hemipenthes sinuosa* (Wiedemann, 1821)**

Figure 12d

Material examined. REC: Apr (3 F); REE: (Feb (1 F), Apr (2 F); RLC: Jul (1 F, 1 M), Sep (1 M); RPA: Sep (2 F).

Known Nearctic records. Mexico (Coahuila, Morelos); USA (Alabama, Arizona, Arkansas, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin).

Known host. *Neodiprion sertifer* Geoff. (Diprionidae).

Comments. *Hemipenthes sinuosa* is only known from Morelos in the center of Mexico and Coahuila in the northeast, but can be found almost in all of the USA. It is clearly undersampled in Mexico.

Genus *Lepidanthrax* Osten Sacken

Remarks. Forty seven of the 52 species of *Lepidanthrax* are from the Nearctic region. Hall (1976) published a revision of this genus including keys for species.

***Lepidanthrax arizonensis* Hall, 1976**

Figure 13a

Material examined. EEO: Mar (1 F); Oct (2 M).

Known Nearctic records. Mexico (Coahuila); USA (Arizona).

Comments. *Lepidanthrax arizonensis* has a restricted distribution, being present only in Arizona and Coahuila, but probably is also present in Chihuahua, Texas and New Mexico.

***Lepidanthrax disiunctus* (Wiedemann, 1830)**

Figure 13b

Material examined. REC: Aug (2 F, 1 M).

Known Nearctic records. Mexico (Coahuila, Distrito Federal, Guerrero, Veracruz); USA (Arizona).

Comments. The distribution of *L. disiunctus* has its northern extreme in Arizona and its southern extreme in Oaxaca, in the southeast of Mexico. It seems this species is rarely collected, but widely distributed.

***Lepidanthrax hesperus* Hall, 1976**

Figure 13c

Material examined. EAM: Apr (2 M); CHU: Apr (2 F, 5 M); ROR: Apr (1 F, 3 M), May (1 F, 1 M); RPA: Apr (1 F, 14 M).

Known Nearctic records. Mexico (Baja California, Coahuila, Sinaloa, Sonora); USA (Arizona, California, New Mexico, Texas).

Comments. This record is the first in northeastern Mexico.

***Lepidanthrax hyposcelus* Hall, 1976**

Figure 13d

Material examined. RLC: Sep (4 F, 15 M).

Known Nearctic records. Mexico (Coahuila, Guerrero, Morelos, Puebla).

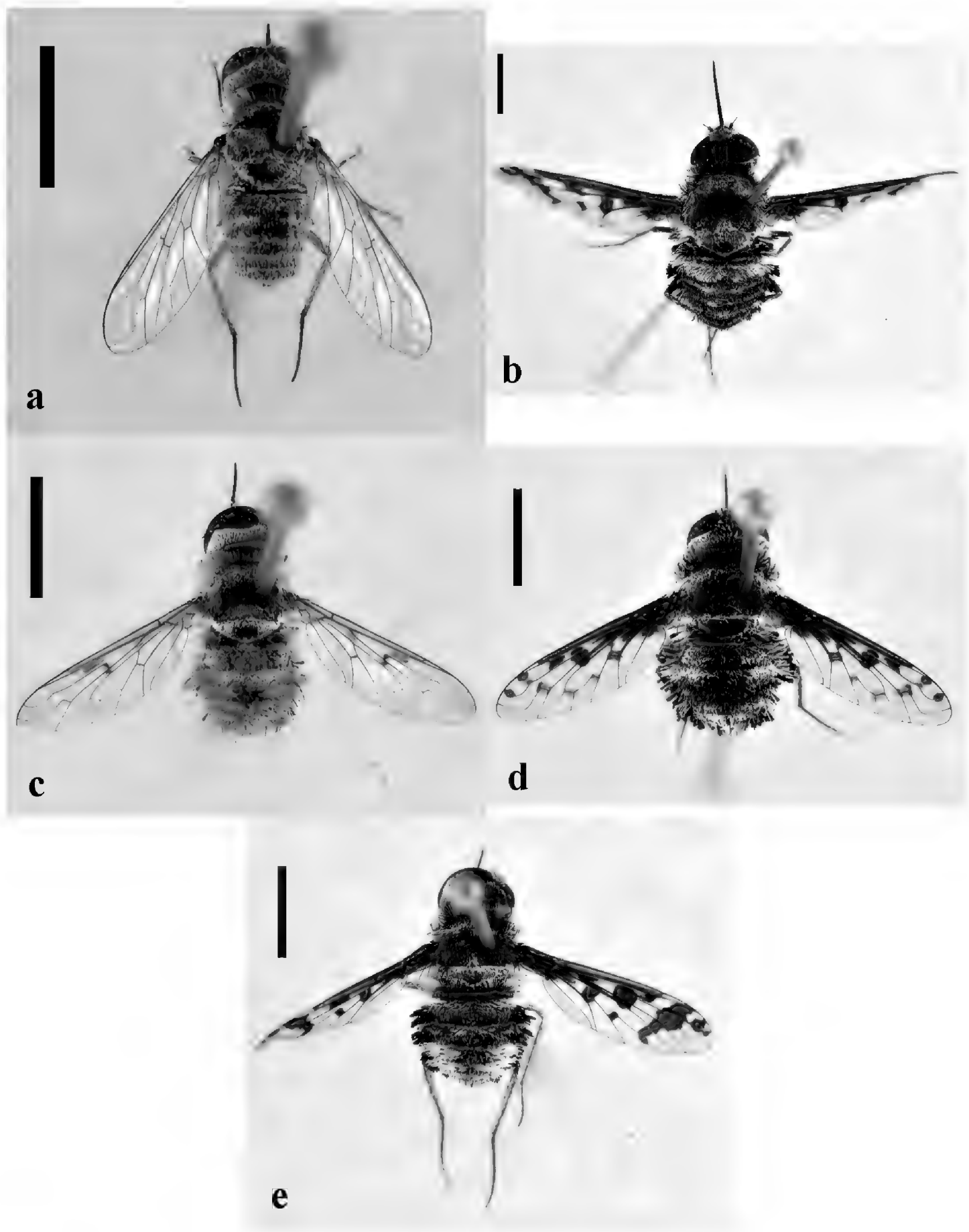


Figure 13. *Lepidanthrax*. **a** *L. arizonensis*, female (CNIN 1352) dorsal view **b** *L. disiunctus* female (CNIN 334) dorsal view **c** *L. hesperus*, male (CNIN 1339) dorsal view **d** *L. hyposcelus*, male (CNIN 369) dorsal view **e** *L. proboscideus*, male (CNIN 357) dorsal view. All scale bars: 3 mm.

Comments. *Lepidanthrax hyposcelus* is endemic to Mexico, previously only known from the southwest of the country; this record extends its distribution to the northeast of the country.

***Lepidanthrax proboscideus* (Loew, 1869)**

Figure 13e

Material examined. ECA: Sep (1 F, 2 M); EEO: Apr (1 F), Aug (1 F, 1 M), Oct (4 F, 15 M); ROR: Sep (2 M); RPA: Sep (2 M), Oct (1 M).

Known Nearctic records. Mexico (Baja California, Baja California Sur, Coahuila, Durango, Guerrero, Morelos, Sonora); USA (Arizona, California, Nevada, New Mexico, Utah).

Comments. *Lepidanthrax proboscideus*, *L. fuscipennis* Hall, 1976 and *L. disiunctus* are the only species of this genus distributed in both the Nearctic and Neotropical regions. Of these *L. proboscideus* extends as far as El Salvador, the most southern distribution for a Nearctic species of this genus. This is the first record of this species in the northeast of Mexico.

Genus *Neodiplocampta* Curran

Remarks. *Neodiplocampta* is a small American genus, more diverse in the Neotropical than the Nearctic region. Hull and Martin (1974) described seven of the 16 species and published a key for all species of the genus.

***Neodiplocampta* (*Neodiplocampta*) *miranda* Hull & Martin, 1974**

Figure 14

Material examined. CHU : Aug (1 F); EEO: Aug (1 F, 1 M); ROR: Jul (1 F); Oct (1 M); RPA: Aug (1 F, 2 M).

Known Nearctic records. Mexico (Coahuila, Guerrero, San Luis Potosi, Sinaloa, Sonora); USA (Arizona, California, Florida, Texas).

Comments. *Neodiplocampta* (*N.*) *miranda* and *N.* (*Agitonia*) *sepia* Hull, 1966 are the only two species distributed in both biogeographic regions (Nearctic and Neotropical). This species is distributed from the south of the USA to Nicaragua, but has not been collected in most Mexican states. This lack of records is possibly due its low abundance.

Genus *Paravilla* Painter

Remarks. Fifty five of the 58 species of the genus are Nearctic. All species of *Paravilla* collected in Coahuila were exclusively collected in the summer months from April to July. Hall (1981a) reviewed this genus and presented a key for species and description of new species.



Figure 14. *Neodiplocampta* (*N.*) *miranda*, female (CNIN 225) dorsal view. Scale bar: 3 mm.

***Paravilla edititoides* (Painter, 1933)**

Figure 15a

Material examined. EAM: Jun (1 M); CHU: Apr (1 F), Jul (2 F, 1 M); ECA: Apr (1 F, 1 M), Jul (1 M); EEO: Apr (1 F, 10 M), May (1 F, 2 M), Jul (9 M); REE: Apr (1 M); RLC: Jun (2 F, 5 M), Jul (1 F); ROR: Jul (1 F, 3 M); RPA: Oct (1 M).

Known Nearctic records. Canada (Saskatchewan); Mexico (Chihuahua, Coahuila, Durango, Jalisco, México, Zacatecas); USA (Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, New Mexico, Oklahoma, Utah, Texas, Wyoming).

Comments. This species is very abundant and present in most of North America, from Canada as far as Jalisco in central Mexico.

***Paravilla flavipilosa* (Cole, 1923)**

Figure 15b

Material examined. CHU: Apr (1 M); Jul (1 M); ECA: Apr (1 M); EEO: Apr (7 M), May (11 M); ROR: Apr (2 M); RPA: Apr (1 M).

Known Nearctic records. Mexico (Baja California Sur, Coahuila, Nuevo León); USA (Arizona, California, Colorado, Texas).

Comments. *Paravilla flavipilosa* is abundant and restricted to the south of the USA and north of Mexico.

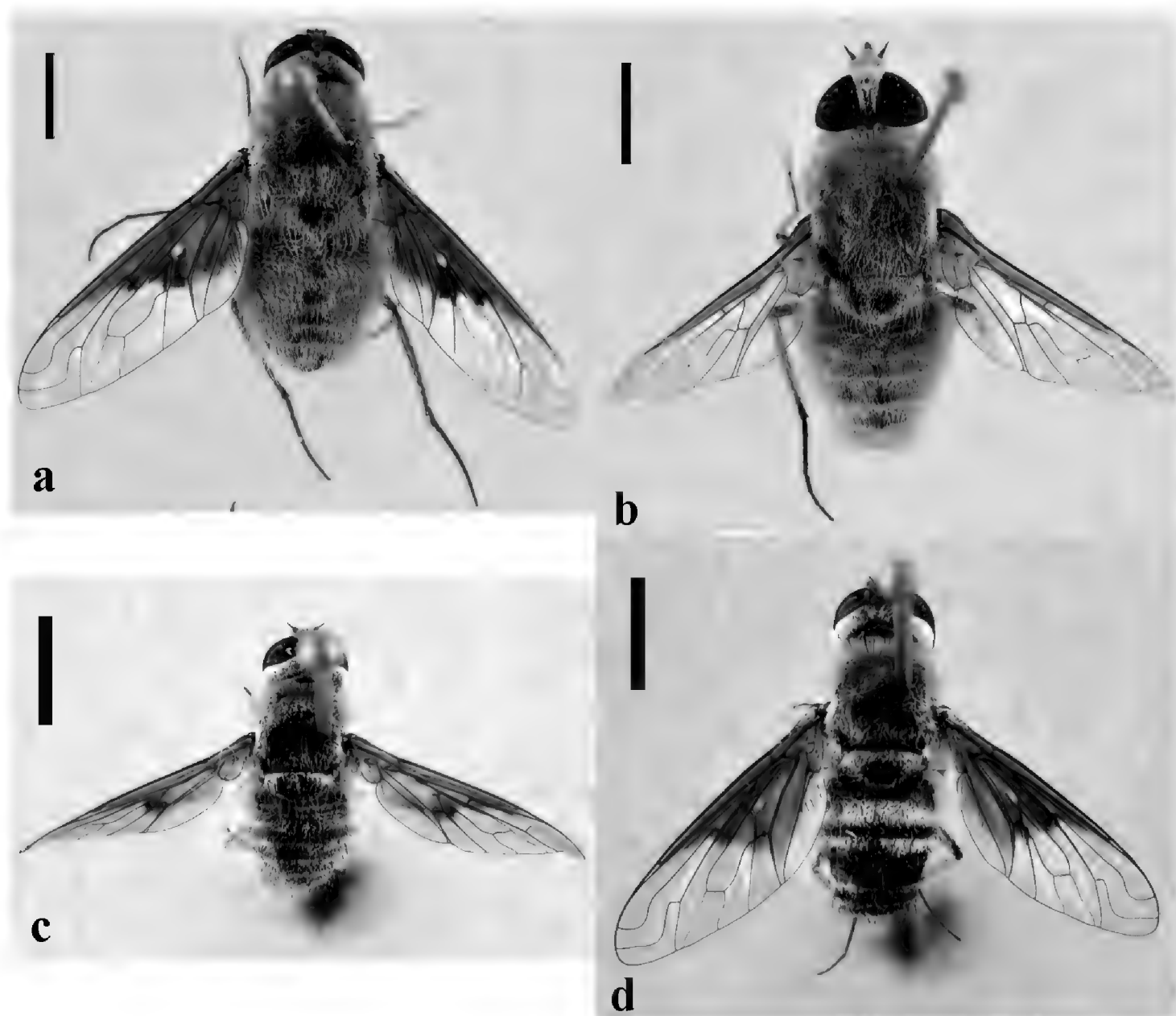


Figure 15. *Paravilla*. **a** *P. edititoides*, male (CNIN 1272) dorsal view **b** *P. flavipilosa*, male (CNIN 1125) dorsal view **c** *P. parvula*, female (CNIN 884) dorsal view **d** *P. separata*, female (CNIN 898) dorsal view. All scale bars: 3 mm.

***Paravilla parvula* Hall, 1981a**

Figure 15c

Material examined. EAM: Apr (1 F); CHU: Apr (1 M); RPA: Apr (7 F, 13 M).

Known Nearctic records. Mexico (Chihuahua, Coahuila, Durango, Guanajuato, Hidalgo, Jalisco, México, Michoacán, Nuevo León, San Luis Potosí, Sonora, Zacatecas), USA (Arizona, New Mexico, Texas, Utah).

Comments. *Paravilla parvula* is relatively well collected in northern and central Mexico. Its distribution also includes the south of the USA but no farther north than Utah.

***Paravilla separata* (Walker, 1852)**

Figure 15d

Material examined. CHU: Apr (1 F); EEO: Apr (3 F); REE: Apr (5 F, 3 M); RPA: Apr (1 M).

Known Nearctic records. Canada (Ontario, Manitoba); Mexico (Coahuila); USA (Alabama, Florida, Georgia, Iowa, Kansas, Michigan, Minnesota, Mississippi, Nebraska, Ohio, South Dakota, Wisconsin).

Comments. *Paravilla separata* is present mainly in the eastern half of the USA, and southeastern Canada. This record in Coahuila represents the southern extreme of the distribution of this species, and is the first in Mexico. It may also be present in Tamaulipas and Nuevo León but doubtfully in the northwest of Mexico.

Genus *Poecilanthrax* Osten Sacken

Remarks. Four species from this mainly Nearctic genus are recorded in Coahuila for the first time. Painter and Hall (1960) published a review of *Poecilanthrax* with a key and images of the species.

Poecilanthrax effrenus (Coquillett, 1887)

Figure 16a

Material examined. EAM: Apr (1 F, 1 M), Jun (1 F, 1 M), Sep (1 F); CHU: Jun (1 F); ROR: May (10 F, 5 M), Jul (2 F, 3 M), Aug (1 M); RPA: Jun (4 F, 1 M), Jul (6 F, 6 M), Aug (1 F, 1 M), Sep (4 F), Oct (2 F, 1 M).

Known Nearctic records. Mexico (Baja California Sur, Chihuahua, Coahuila, Sonora, Tamaulipas); USA (Arizona, California, New Mexico, Oklahoma, Texas).

Comments. This record fills a gap in *P. effrenus* distribution between northwest and northeast populations of Mexico. This species is probably present in Baja California and Nuevo León, but has not yet been recorded.

Poecilanthrax fasciatus Johnson & Johnson, 1957

Figure 16b

Material examined. EAM: Sep (1 M); CHU: Oct (1 M); ROR: Oct (1 M); RPA: Oct (1 M).

Known Nearctic records. Mexico (Coahuila); USA (Colorado, Kansas, Texas).

Known host. *Chorizagrotis auxiliaris* Grote (Noctuidae).

Comments. *Poecilanthrax fasciatus* is collected in Mexico for the first time, and this extends the southern limit of this species distribution.

Poecilanthrax hyalinipennis Painter & Hall, 1960

Figure 16c

Material examined. EAM: Mar (3 M), Oct (1 F); CHU: Oct (1 M); ROR: Oct (4 M); RPA: Sep (1 F), Oct (2 F, 6 M).

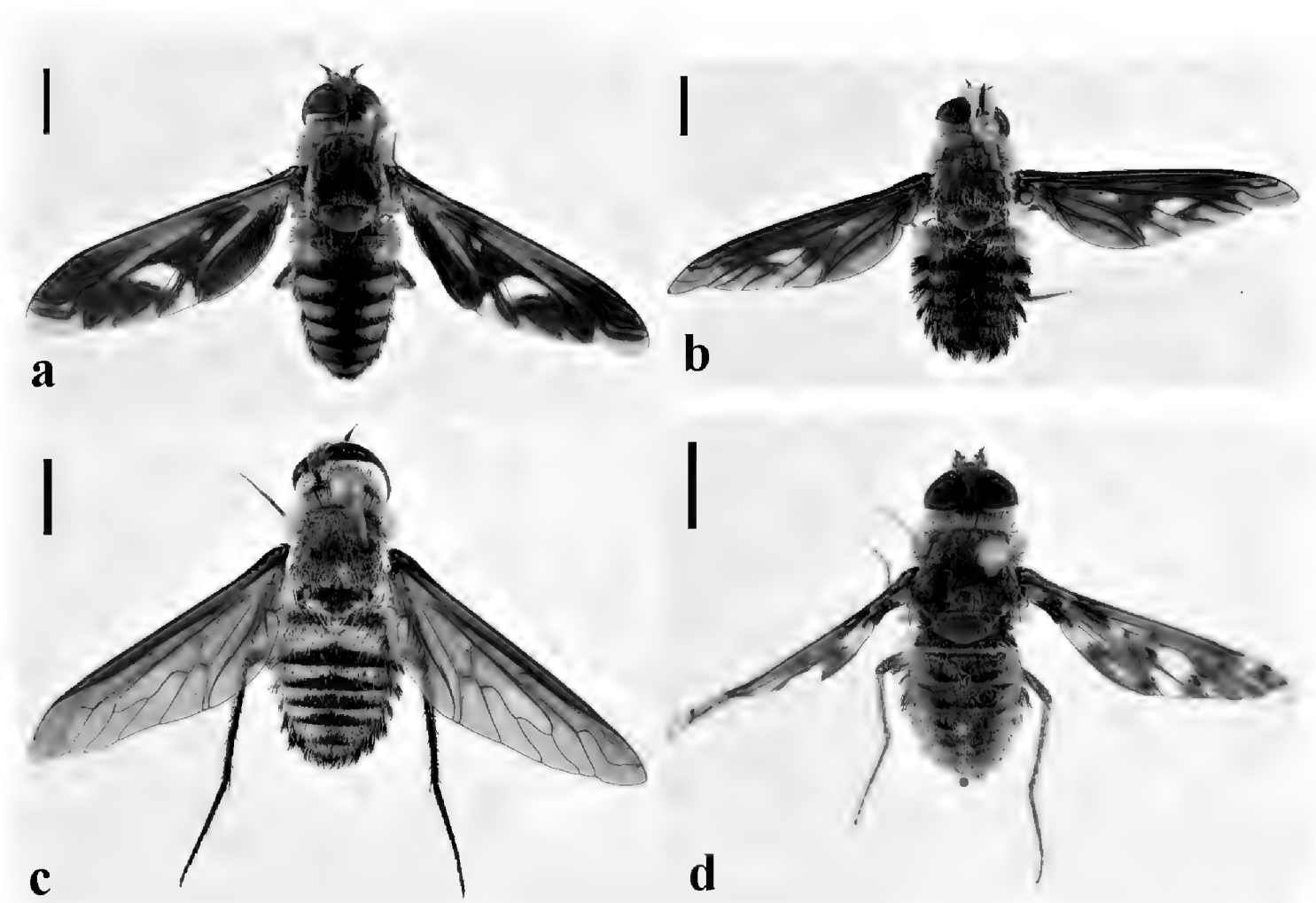


Figure 16. *Poecilanthrax*. **a** *P. effrenus*, female (CNIN 1380) dorsal view **b** *P. fasciatus*, male (CNIN 218) dorsal view **c** *P. hyalinipennis*, female (CNIN 1365) dorsal view **d** *P. poecilogaster*, male (CNIN 1356) dorsal view. All scale bars: 3 mm.

Known Nearctic records. Mexico (Coahuila); USA (Arizona, California, Nevada, Utah).

Comments. This record extends the distribution of *P. hyalinipennis* into the northwest of Mexico. Considering its distribution in the USA, this species may also be present in the northeast of Mexico.

***Poecilanthrax poecilogaster* (Osten Sacken, 1886b)**

Figure 16d

Material examined. REE: Apr (2 M).

Known Nearctic records. Canada (Alberta, Manitoba, Ontario, Saskatchewan); Mexico (Coahuila, Morelos, Nuevo León, Sonora); USA (Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah).

Comments. Most of the records in the USA and Mexico of this rarely collected but widespread species are from Pacific Coast states, although, there are records from Nuevo Leon and Coahuila in northeast Mexico.

Genus *Rhynchanthrax* Painter

Remarks. Of the seven species of this exclusively Nearctic genus, six are present in Mexico, with *R. maria* (Williston, 1901) and *R. nigrofimbriatus* (Williston, 1901) being endemic to this country. Only *Rhynchanthrax parvicornis* (Loew, 1869) has not been collected in Mexico, but it is distributed across the southern USA and may also occur in the north of Mexico.

Rhynchanthrax capreus (Coquillett, 1887)

Figure 17a

Material examined. CHU: Apr (1 M), Aug (13 F, 6 M), Jul (12 F, 6 M), Sep (1 F, 3 M).

Known Nearctic records. Mexico (Coahuila); USA (Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Utah).

Comments. This is the first record of this species in Mexico. *Rhynchanthrax capreus* is the only species occurring in the northwest of the USA, while the other species in the genus are present mainly in the south and east of the country. This species may also be present in the northwest of Mexico (Baja California, Sonora, Chihuahua).

Rhynchanthrax texanus (Painter, 1933)

Figure 17b

Material examined. EEO: May (1 M); RLC: Jun (1 F, 11 M), Jul (3 M).

Known Nearctic records. Mexico (Coahuila, Sonora); USA (Kansas, New Mexico, Texas).

Comments. This is the most eastern record in Mexico for this species. In the USA it is distributed in the southern-center of the country, but in Mexico it has been collected in Sonora so it probably also occurs in Arizona.

Genus *Thyridanthrax* Osten Sacken

Remarks. *Thyridanthrax* has twice as many species in the Palearctic region as in the Nearctic and Neotropical regions combined. All 12 species in North America are present in the USA with five also in Mexico. These are the first records of this genus in Coahuila. The distribution of *T. selene* (Osten Sacken, 1886b) and *T. pallidus* (Coquillett, 1887) are very similar, being present in all of the southern USA and probably also in all of northern Mexico, although they have been only collected in Sonora and Coahuila to date. Both species are rare and were collected only in April.



Figure 17. *Rhynchanthrax*. **a** *R. capreus*, female (CNIN 940) dorsal view **b** *R. texanus*, male (CNIN 263) dorsal view. All scale bars: 3 mm.

***Thyridanthrax pallidus* (Coquillett, 1887)**

Figure 18b

Material examined. REE: Apr (4 F, 1 M).

Known Nearctic records. Mexico (Coahuila); USA (Arizona, California, Nevada, Texas, Utah).

Comments. This represents the first record of this species in Mexico.

***Thyridanthrax selene* (Osten Sacken, 1886b)**

Figure 18a

Material examined. EAM: Apr (1 M); REE: Apr (2 F, 2 M).

Known Nearctic records. Mexico (Coahuila, Sonora); USA (Arizona, California, Texas).

Comments. This is the most eastern record in Mexico.

Genus *Xenox* Evenhuis

Remarks. Of the five species that constitute this genus, four are present in Mexico.

***Xenox xylocopae* (Marston, 1970)**

Figure 19

Material examined. ECA: Sep (1 M).

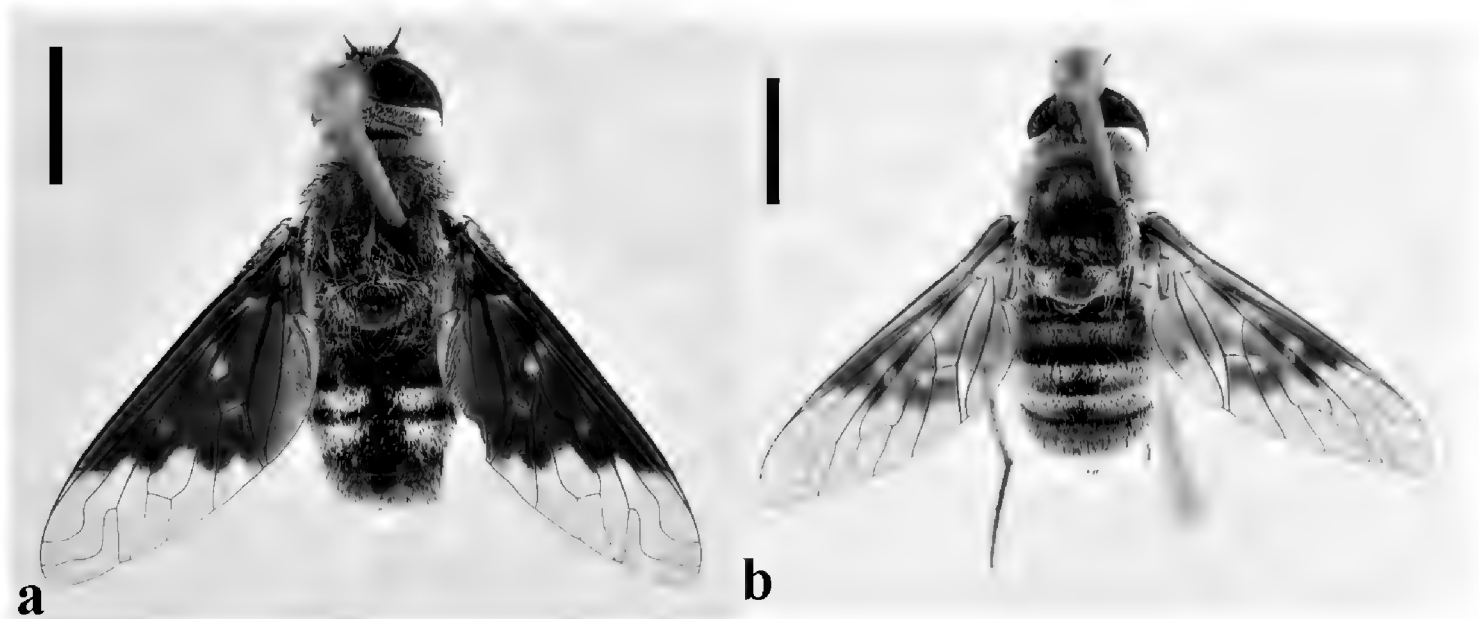


Figure 18. *Thyridanthrax*. **a** *T. selene*, male (CNIN 182) dorsal view **b** *T. pallidus*, female (CNIN 1162) dorsal view. All scale bars: 3 mm.



Figure 19. *Xenox xylocopae*, male (CNIN 1165) dorsal view. Scale bar: 3 mm.

Known Nearctic records. Mexico (Chihuahua, Coahuila, Sonora), USA (Arizona, New Mexico, Texas).

Known host. *Xylocopa micheneri micheneri* (Hurd) (Apidae) as reported by Minckley (1989).

Comments. *Xenox xylocopae* appears to be restricted to the northeast of Mexico and south of the USA. Three of the other species also have restricted and separate distributions: *X. delila* Loew, 1869 is present in the northwest of Mexico and California; *X. nigrinus* (Schaeffer, 1768) occurs from the northeast of Mexico (Veracruz and Tamaulipas without overlap with *X. xylocopae*) to South America; and *X. tigrinus* (De Geer, 1776) is present in the eastern USA and southern Ontario. Only *X. habrosus* (Marston, 1970) has a distribution overlapping with the other four species, being present in all of Mexico and the southwest of the USA.

Discussion

The data presented here increase the knowledge of Bombyliidae in Mexico but also reveals the deficiencies in sampling of the family in the country. The species list for the state increased three-fold, which demonstrates the lack of knowledge of the Bombyliidae fauna in this region. Almost all states of Mexico are in a similar situation but northern states appear to have higher diversity and should be priorities for sampling. Hull (1973) identified the northwest of Mexico as a species concentration area of Bombyliidae, but the northeast portion of the country may have the same species richness. Diversity of this family in the north of Mexico is probably much higher than recorded, as indicated by the richness in the south of USA which has similar environmental characteristics but much better sampling. Therefore northeast Mexico is possibly one of the most under sampled areas in the Nearctic region for Bombyliidae, given the great diversity of this family in the area, combined with the size of this part of the country. The study of Bombyliidae in the northern states of Mexico should be more of a priority than field work in the center or the southern states.

Most of the species collected in this study have a broad distribution in the USA but Mexican records are isolated. There are probably more species yet to be recorded from Coahuila and other Mexican states, especially species present in southern border states of the USA. Some species are recorded only from Coahuila in the northeast of Mexico but are also present in the northwest of the country. More studies are required to determine if these species have a disjunct distribution or if any are represented by distinct, cryptic eastern and western species.

Cuatro Ciénegas' biological and conservational importance has long been recognized for reptiles (McCoy 1984), birds (Contreras-Balderas 1984), plants (Pinkava 1984, Villarreal and Encina 2005), snails (Hershler 1984), Crustacea (Cole 1984) and particularly fishes (Minckley 1984), but little is known of other groups like insects. The insects contain 53% of the described species in the planet (Chapman 2009), so their distribution and diversity should be considered for conservation and natural reserve design. The diversity of insects, especially of Bombyliidae and similar arid-regions-diverse groups, increases the conservational value of Cuatro Ciénegas.

Conclusions

The data presented here indicates the significance of Cuatro Ciénegas for Bombyliidae diversity. Comparison with other nearby areas should be undertaken to confirm whether this area really is richer for this family. Data also reveal that true species richness of Bombyliidae is much higher than previously recorded. This could also be true for other insect groups. More funding should be destined for faunistic studies of megadiverse groups with ecological importance such as Diptera, Coleoptera, Hymenoptera and Lepidoptera. The information obtained from these studies might be used first to quantify the species richness and species exchange between areas (beta diversity) (Whittaker 1972) and later to propose conservation management schemes.

Acknowledgments

Support for field work was provided by grants from CONABIO (JF065) to A. Nieto, from CONACyT to O. Ávalos-Hernández (CVU 226224) and from resources of the WWF-Alianza Carlos Slim (L039) and the Theodore Roosevelt Memorial Fund (American Museum of Natural History) provided to M. Trujano-Ortega and U. García-Vázquez. We thank A. Arellano, E. Austria, A. Contreras, J. Hernández, H. Ortega, PRONATURA A. C., DESUVALLE A.C. and CONANP for their assistance in the field work. We also thank H. Braylovsky and C. Mayorca for allowing access to the CNIN-IBUNAM; and to J. Llorente and A. Luis from the MZFC-UNAM for their assistance and for providing part of the collecting and preparation material. We thank Dr. Christine Lambkin, an anonymous reviewer, and the editor for their constructive comments, which helped us to improve the manuscript. Lastly we thank the Posgrado en Ciencias Biológicas of the Universidad Nacional Autónoma de México for its support. This work is part of the Ph.D. research project of O. Ávalos-Hernández.

References

- Ávalos-Hernández O (2007) Bombyliidae (Insecta: Diptera) de Quilamula en el área de reserva Sierra de Huautla, Morelos, México. *Acta Zoológica Mexicana* (n.s.) 23: 139–169. <http://www.redalyc.org/pdf/575/57523111.pdf>
- Ávalos-Hernández O (2009) A review of the North American species of *Hemipenthes* Loew, 1869 (Diptera: Bombyliidae). *Zootaxa* 2074: 1–49. <http://www.mapress.com/zootaxa/2009/f/z02074p049f.pdf>
- Bigot JMF (1892) Diptères nouveaux ou peu connus. 37e partie. XLVI Bombylidi (mihi) 1er partie. *Annales de la Société Entomologique de France* 61: 321–376.
- Boesi R, Polidori C, Andrietti F (2009) Searching for the right target: oviposition and feeding behavior in *Bombylius* bee flies (Diptera: Bombyliidae). *Zoological Studies* 48: 141–150. <http://zoolstud.sinica.edu.tw/Journals/48.2/141.pdf>

- Chapman AD (2009) Numbers of Living Species in Australia and the World. 2nd edition. Australian Biodiversity Information Services, Toowoomba, 80 pp. <http://www.environment.gov.au/node/13875>
- Cole FR (1923) Expedition on the California Academy of Sciences to the Gulf of California in 1921. The Bombyliidae (bee flies). Proceedings of the California Academy of Sciences 12: 289–314. https://archive.org/details/cbarchive_52779_expeditionofthecaliforniaacade1907
- Cole GA (1984) Crustacea from the Bolson of Cuatro Ciénegas, Coahuila, Mexico. Journal of the Arizona-Nevada Academy of Science 19: 3–12. <http://www.jstor.org/stable/40024285>, https://archive.org/details/cbarchive_52779_expeditionofthecaliforniaacade1907
- Contreras-Balderas AJ (1984) Birds from Cuatro Ciénegas, Coahuila, Mexico. Journal of the Arizona-Nevada Academy of Science 19: 77–79. www.jstor.org/stable/40024290
- Coquillett DW (1886) The North American species of *Toxophora*. Entomologica Americana 1: 221–222.
- Coquillett DW (1887) Monograph of the species belonging to the genus *Anthrax* from America Northern Mexico. Transactions of the American Entomological Society 14: 159–182. doi: 10.2307/25076488
- Coquillett DW (1891) New Bombyliidae from California. West American scientist 7: 197–200.
- Coquillett DW (1894) Notes and descriptions of North American Bombyliidae. Transactions of the American Entomological Society 21: 89–112.
- Cresson ET (1919) Dipterological notes. II. A study of the lateralis-group of the bombyliid genus *Villa* (*Anthrax* of authors, in part). Entomological News 27: 439–444.
- Cunha AM, Lamas CJE, Couri MS (2007) Revision of the New World bee fly genus *Heterostylum* Macquart (Diptera, Bombyliidae, Bombyliinae). Revista Brasileira de Entomologia 51: 12–22. doi: 10.1590/s0085-56262007000100004
- Cunha AM, Lamas CJE, Couri MS (2011) Taxonomic notes, new species and identification key to the New World species of *Toxophora* Meigen (Diptera, Bombyliidae, Toxophorinae). Zootaxa 3038: 51–58. <http://www.mapress.com/zootaxa/2011/f/z03038p058f.pdf>
- De Geer C (1776) Mémoires pour servir a l’histoire des insects. Tome sixieme. P. Hesselberg, Stockholm, 523 pp.
- Evenhuis NL (1984) Revision of the *Bombylius comanche* group of the new World (Diptera: Bombyliidae). International Journal of Entomology 26: 291–321.
- Evenhuis NL (1989) Family Bombyliidae. In: Evenhuis NL (Ed) Catalog of the Diptera of the Australasian and Oceanian Regions. Bishop Museum Press, Honolulu and E.J. Brill, Leiden, 359–374. doi: 10.1002/mmnd.19920390412
- Evenhuis NL, Greathead DJ (1999) World catalogue of bee flies (Diptera: Bombyliidae). Backhuys Publishers, Leiden, 756 pp. <http://hbs.bishopmuseum.org/bombcat/>
- Fabricius JC (1805) Systema antliatorum secundum ordines, genera, species adiecta synonymis, locis, observationibus, descriptionibus. C. Reichard, Brunsvigae, 372 pp. doi: 10.5962/bhl.title.15806
- Hall JC (1954) A revision of the genus *Lordotus* Loew in North America (Diptera: Bombyliidae). University of California Press, Berkley and Los Angeles, 33 pp.
- Hall JC (1975) The North American species of *Triploechnus* Edwards (Diptera: Bombyliidae). The Pan-Pacific Entomologist 51: 49–56.

- Hall JC (1976) A revision of the North and Central American species of *Lepidanthrax* Osten Sacken (Diptera: Bombyliidae). Transactions of the American Entomological Society 102: 289–371.
- Hall JC (1981a) A review of the North and Central American species of *Paravilla* Painter (Diptera: Bombyliidae). University of California Publications in Entomology 92: 1–190.
- Hall JC (1981b) Bombyliidae. In: McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (Eds) Manual of Nearctic Diptera, vol. 1. Chapter 45. 589–602. Monograph, Research Branch, Agriculture Canada, 674 pp. doi: 10.1163/187631283x00074
- Hall JC, Evenhuis NL (1980) Bombyliidae. In: Griffiths GCD (Ed) Flies of the Nearctic Region. E. Schweizerbart, Stuttgart. Vol. V, pt. 13, no. 1, 1–96. doi: 10.1163/187631283x00100
- Hall JC, Evenhuis NL (1981) Bombyliidae. In: Griffiths GCD (Ed) Flies of the Nearctic Region. E. Schweizerbart, Stuttgart. Vol. V, pt. 13, no. 2, 97–184. doi: 10.1163/187631283x00100
- Hall JC, Evenhuis NL (1982) Bombyliidae. In: Griffiths GCD (Ed) Flies of the Nearctic Region. E. Schweizerbart, Stuttgart. Vol. V, pt. 13, no. 3, 185–280. doi: 10.1163/187631283x00100
- Hershler R (1984) The Hybrobiid snails (Gastropoda: Rissoacea) of the Cuatro Ciénegas Basin: systematic relationships and ecology of a unique fauna. Journal of the Arizona–Nevada Academy of Science 19: 61–76.
- Hull FM (1966) Notes on the genus *Neodiplocampta* Curran and certain other Bombyliidae, Part I. Entomological News 77: 225–227. <http://biostor.org/reference/84710>
- Hull FM (1973) Bee flies of the world. The genera of the family Bombyliidae. Smithsonian Institution Press, Washington, D.C., 687 pp. doi: 10.5962/bhl.title.48406
- Hull FM, Martin WC (1974) The genus *Neodiplocampta* Curran, and related bee flies (Diptera: Bombyliidae). Proceedings of The Entomological Society of Washington 76: 322–346. <http://biostor.org/reference/84256>
- Johnson CW (1902) New North American Diptera. Canadian Entomologist 34: 240–242. doi: 10.4039/Ent34240-9
- Johnson DE, Johnson LM (1957) New *Poecilanthrax*, with notes on described species (Diptera: Bombyliidae). Great Basin Naturalist 17: 1–26. <http://www.jstor.org/stable/41710977>
- Johnson DE, Johnson LM (1958) New and insufficiently known *Exoprosopa* from the far west (Diptera: Bombyliidae). Great Basin Naturalist 18: 69–84.
- Johnson DE, Johnson LM (1959) Notes on the genus *Lordotus* Loew, with descriptions of new species (Diptera: Bombyliidae). Great Basin Naturalist 19: 67–74. <http://www.jstor.org/stable/41711014>
- Kearns CA (2001) North American dipteran pollinators: assessing their value and conservation status. Conservation Ecology 5: 5. <http://www.consecol.org/vol5/iss1/art5/>
- Kits JH, Marshall SA, Evenhuis NL (2008) The bee flies (Diptera: Bombyliidae) on Ontario, with a key to the species of eastern Canada. Canadian Journal of Arthropod Identification 6: 1–52. doi: 10.3752/cjai.2008.06
- Loew H (1863) Diptera Americae septentrionalis indigena. Centuria quarta. Berliner Entomologische Zeitschrift 7: 275–326.
- Loew H (1869) Diptera Americae septentrionalis indigena. Centuria octava. Berliner Entomologische Zeitschrift, 13, 1–52.
- Macquart PJM (1934) Histoire naturelle des insectes. Dipteres. Ouvrage accompagné de planches. Tome premier. N.E. Roret, Paris, 578 pp. doi: 10.5962/bhl.title.14274

- Marston N (1963) A revision of the Nearctic species of the *albofasciatus* group of the genus *Anthrax* Scopoli (Diptera: Bombyliidae). Technical Bulletin of the Kansas State University Agricultural Experiment Station 127: 1–79.
- Marston N (1970) Revision of New World species of *Anthrax* (Diptera: Bombyliidae), other than the *Anthrax albofasciatus* group. Smithsonian Institution Press, Washington, D.C., 149 pp. doi: 10.5479/si.00810282.43
- McCoy CJ (1984) Ecological and zoogeographic relationships of amphibians and reptiles of the Cuatro Ciénegas Basin. Journal of the Arizona-Nevada Academy of Science 19: 49–59. <http://www.jstor.org/stable/40024288>
- Melander AL (1950) Taxonomic notes on some smaller Bombyliidae (Diptera). The Pan-Pacific Entomologist 26: 145–156.
- Minckley WL (1984) Cuatro Ciénegas fishes: research review and a local test of diversity versus habitat size. Journal of the Arizona-Nevada Academy of Science 19: 13–21.
- Minckley RL (1989) Host records and biological notes for two *Anthrax* species in Arizona: (Diptera: Bombyliidae). Journal of the Kansas Entomological Society 62: 274–278.
- Moreno-Letelier A, Olmedo-Alvarez G, Eguiarte LE, Souza V (2012) Divergence and phylogeny of firmicutes from Cuatro Ciénegas Basin, Mexico: A window to an ancient ocean. Astrobiology 12: 674–684. doi: 10.1089/ast.2011.0685
- Motten AF, Campbell DR, Alexander DE, Miler HL (1981) Pollination effectiveness of specialist and generalist visitors to a North Carolina population of *Claytonia virginica*. Ecology 62: 1278–1287. doi: 10.2307/1937292
- Osten Sacken CR (1877) Western Diptera: descriptions of new genera and species of Diptera from the region west of the Mississippi, and especially from California. Bulletin of the Geological and Geographical Survey of the Territories 3: 189–354. doi: 10.5962/bhl.title.57939
- Osten Sacken CR (1886a) Diptera. In: Godman FD, Salvin O (Eds) Biologia Centrali Americana, Zoology, Insecta, Diptera, Vol. 1. Taylor and Francis, London, 73–104. doi: 10.5962/bhl.title.66719
- Osten Sacken CR (1886b) Diptera. In: Godman FD, Salvin O (Eds) Biologia Centrali Americana, Zoology, Insecta, Diptera, Vol. 1. Taylor and Francis, London, 105–128. doi: 10.5962/bhl.title.66719
- Osten Sacken CR (1887) Diptera. In: Godman FD, Salvin O (Eds) Biologia Centrali Americana, Zoology, Insecta, Diptera, Vol. 1. Taylor and Francis, London, 129–160. doi: 10.5962/bhl.title.66719
- Painter RH (1930) Review of the bombyliid genus *Heterostylum* (Diptera). Journal of the Kansas Entomological Society 3: 1–7. <http://www.jstor.org/stable/25081279>
- Painter RH (1933) New subgenera and species of Bombyliidae (Diptera). Journal of the Kansas Entomological Society 6: 5–18. <http://www.jstor.org/stable/25081346>
- Painter RH (1940) Notes on type specimens and descriptions of the new North American Bombyliidae. Transactions of the Kansas Academy of Science 42: 267–301. <http://www.jstor.org/stable/3625084>
- Painter RH, Hall JC (1960) A monograph of the genus *Poecilanthrax* (Diptera: Bombyliidae). Technical Bulletin of the Kansas State University Agricultural Experiment Station 106: 1–132.

- Painter RH, Painter EM (1962) Notes and redescrptions of types of North American Bombyliidae (Diptera) in European Museums. *Journal of the Kansas Entomological Society* 35: 1–164. <http://www.jstor.org/stable/25083238>
- Painter RH, Painter EM (1969) New Exoprosopinae from Mexico and Central America (Diptera: Bombyliidae). *Journal of the Kansas Entomological Society* 42: 5–34. <http://www.jstor.org/stable/25083759>
- Pape T, Blagoderov V, Mostovski MB (2011) Order Diptera Linnaeus, 1758. In: Zhang ZQ (Ed) *Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness*. *Zootaxa* 3148: 212–221. <http://www.mapress.com/zootaxa/2011/f/zt03148p229.pdf>
- Pinkava DJ (1979) Vegetation and flora of the Bolson of Cuatro Ciénegas region, Coahuila, Mexico: I. *Boletín de la Sociedad Botánica de México* 38: 35–151.
- Pinkava DJ (1984) Vegetation and flora of the Bolson of Cuatro Ciénegas region, Coahuila, Mexico: IV, Summary, endemism and corrected catalogue. *Journal of the Arizona-Nevada Academy of Science* 19: 23–47. <http://www.jstor.org/stable/40024287>
- Rodríguez-Ortuño V (1989) Estudio faunístico de los Bombyliidae (Diptera) Cañón de Lobos, Morelos, México. Graduate thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México, México.
- Say T (1823) *American entomology, or descriptions of the insects of North America; illustrated by coloured figures from original drawings executed from nature*, Vol. I. S. A. Mitchell, Philadelphia, 101 pp. doi: 10.5962/bhl.title.9156
- Schaeffer JC (1768) *Icones insectorum circa Ratisbonam indifenorum coloribus naturam referentibus expressae. Natürlichk ausgemahlte Abbildungen regensburgischer Insecten*. Volvm. I Pars II. Ersten Bandes erster Theil. H.G. Zunkel, Ratisbonae, 50 pp.
- Scott VL, Strickler K (1992) New host records for two species of *Anthrax* (Diptera: Bombyliidae). *Journal of the Kansas Entomological Society* 65: 393–402. <http://www.jstor.org/stable/25085388>
- Souza V, Espinosa-Asuar L, Escalante AE, Eguiarte LE, Farmer J, Forney L, Lloret L, Rodríguez-Martínez JM, Soberón J, Dirzo R, Elser JJ (2006) An endangered oasis of aquatic microbial biodiversity in the Chihuahuan desert. *PNAS* 103: 6565–6570. doi: 10.1073/pnas.0601434103
- Souza V, Siefert JL, Escalante AE, Elser JJ, Eguiarte LE (2012) The Cuatro Ciénegas Basin in Coahuila, Mexico: an astrobiological precambrian park. *Astrobiology* 12: 641–647. doi: 10.1089/ast.2011.0675
- Tucker ES (1907) Some results of desultory collecting of insects in Kansas and Colorado. *The Kansas University Science Bulletin* 4: 51–112.
- Villarreal Quintanilla JA, Encina Domínguez JA (2005) Plantas vasculares endémicas de Coahuila y algunas áreas adyacentes, México. *Acta Botánica Mexicana* 70: 1–46. <http://www.redalyc.org/articulo.oa?id=57407001>
- Walker F (1849) List of specimens of dipterous insects in the collection of the British Museum. Parts II-IV. British Museum, London, 1172 pp.
- Walker F (1852) *Insecta Saudersiana: or characters of undescribed insects in the collection of William Wilson Saunders, Esq., F.R.S., F.L.S. and c., Vol. 1 Diptera (Part 3)*. J. Van Voorst, London, 474 pp. doi: 10.5962/bhl.title.66010

- Whittaker RH (1972) Evolution and measurement of species diversity. *Taxon* 21: 213–251. doi: 10.2307/1218190
- Wiedemann CRW (1821) *Diptera Exotica* (ed. 2) Pars I. Tabulis aeneis duabus, Kiel, 101 pp.
- Wiedemann CRW (1828) *Aussereuropäische zweiflügelige Insekten. Als Fortsetzung des Meigenschen Werkes. Erster Theil.* Schulz, Hamm, 608 pp. doi: 10.5962/bhl.title.14603
- Wiedemann CRW (1830) *Aussereuropäische zweiflügelige Insekten. Als Fortsetzung des Meigenschen Werkes. Zweiter Theil.* Schulz, Hamm, 684 pp. doi: 10.5962/bhl.title.14603
- Williston SW (1893) New or little known Diptera. *Kansas University Quarterly* 2: 59–78.
- Williston SW (1901) Supplement. In: Godman FD, Salvin O (Eds) *Biologia Centrali Americana, Zoology, Insecta, Diptera, Vol. 1.* Taylor and Francis, London, 273–296.
- Yeates DK, Greathead DJ (1997) The evolutionary pattern of host use in the Bombyliidae (Diptera): a diverse family of parasitoid flies. *Biological Journal of the Linnean Society* 60: 149–185. doi: 10.1111/j.1095-8312.1997.tb01490.x